Foreign Currency Bank Funding and Global Factors

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Abstract

The literature on the drivers of international capital flows establishes the importance of global financial risk factors. However, the cross country and time variation in the sensitivity of capital flows to global factors is substantial and not well understood. We present a portfolio balance model suggesting that the foreign currency mismatch on financial institutions' balance sheets determine the size and sign of these institutions' cross border flows in response to global risk factors. Testing the model for European banks' net foreign currency funding flows yields supporting evidence, especially for countries that are not members of the euro area.

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1 Introduction

How do capital flows respond to global risk factors? It is well established in the empirical literature that conditions in global financial markets, such as global risk sentiment, volatility and liquidity, drive cross border capital flows (e.g. Calvo et al. [1996], Forbes and Warnock [2012a], Rey [2015], Cerutti et al. [2016]). Global financial factors have traditionally been viewed as push factors in the literature, impacting capital flows irrespective of the fundamentals of recipient countries. Accordingly, they are usually modelled as having a uniform impact on capital flows over time and across countries. Recent empirical studies point to substantial cross country variation in the response of cross border capital flows to global financial factors, however, and to changes in the sensitivity of capital flows to global factors over time (e.g. Avdjiev et al. [2016c], Cerutti et al. [2017]). These patterns are not just a reflection of differences between emerging markets and advanced economies, as time and cross country variation is also manifested within these sets of countries (Goldberg and Krogstrup [2016]). It underscores that country specific features play a role in determining a country's capital flow sensitivity to global factors and, hence, capital flow volatility.

An understanding of how country specific features drive capital flow sensitivity to global factors can help inform the design of capital flow management measures. The literature on the drivers of capital flow sensitivity to global factors is scarce, however. Two recent empirical studies suggest that the types of foreign investors and domestic financial institutions intermediating a country's cross border capital flows play a role (IMF [2014], Cerutti et al. [2015])), although the exact mechanisms remain unexplored. Cross country comparable data on the financial market structure underlying cross border flows are limited, and there is, to our knowledge, no theoretical literature investigating the determinants of a country's capital flow sensitivity to global risk factors.

This paper contributes to the theoretical as well as the empirical understanding of the drivers of a country's capital flow sensitivity to global factors. Building on the role of financial institutional structure underlined in IMF [2014] and Cerutti et al. [2015], we focus on the role of the balance sheet structure of a country's financial institutions and illustrate that their foreign currency mismatch can affect the sign and size of the response of capital flows to global risk factors. The mechanism is the following. Financial institutions choose their foreign currency exposure to maximize a risk-adjusted return on their total portfolio. When the risk associated with their foreign currency exposure increases, a country's resident financial institutions will respond by reducing their foreign currency exposure, given expected returns. Reducing foreign currency exposure, however, has different implications for the direction of the resulting cross border flow depending on the sign of financial institutions' foreign currency mismatch. If financial institutions have a short foreign currency exposure, e.g. have more foreign currency funding than foreign currency lending, reducing this exposure requires a reduction in foreign currency funding, or an increase of foreign currency lending. This invariably means that a country with financial institutions that are mostly net short foreign currency will see a net capital outflow in response to higher global risk. The opposite response of cross border flows ensues if a country's resident financial institutions are initially long in foreign currency exposure, e.g. have more foreign currency lending than foreign currency funding. In this case, reducing the exposure to foreign risks requires a reduction in foreign currency lending or an increase in foreign currency funding.

The model setup that we propose for illustrating these mechanisms is that of a simple portfolio model of a bank's choice of net wholesale funding denominated in foreign currency, which we associate with cross border funding. The bank maximizes the expected future value of its equity under exchange rate uncertainty, and adjusts its mix of domestic and foreign currency wholesale funding in response to changes in global risk and risk aversion. It has access to a global on-balance sheet funding market and a forward currency market, both in domestic and foreign currency. The forward market allows us to account theoretically for the possibility that banks use off-balance sheet instruments to manage foreign currency exposure. To keep the model tractable, we assume that the bank is small and residing in a small country, and does not take account of the effects of its decisions on global markets and prices. Extensions toward general equilibrium would be desirable but are beyond the scope of this paper.

We find that the bank trades off the riskiness of a net foreign currency exposure with the return to having such an exposure, and thus, that a positive amount of net foreign currency exposure will be an optimal decision in the general case where funding costs differ across currencies. The sign of the foreign currency mismatch depends on differences in cross currency funding costs, and its extent will depend on country specific institutional factors such as risk preferences and equity financing, which we for simplicity treat as exogenous.[1]

Given the bank's preferred foreign currency exposure, the model in turn illustrates how an increase in the perceived riskiness of this exposure, given expected funding costs, leads the bank to seek to reduce it. If the bank is long foreign currency, reducing this long exposure is indeed achieved through an increase in net foreign currency funding, giving rise to a cross border inflow. Conversely, if the financial institution is net short, it will reduce its exposure by reducing its net foreign currency funding, which hence gives rise to a cross border outflow.

The model allows us to derive a simple expression for foreign currency funding flows as a

[1] In future extensions to this model, such determinants should be linked more broadly with macroeconomic policy outcomes that affect interest rate levels across countries.

function of changes in global risk factors, pre-existing currency exposures, and other determinants of the risk and return of funding positions, from which we derive an empirical estimating equation. This estimating equation is then taken to the data for cross border bank funding flows in foreign currency. Even though the model predictions extend more generally to flows associated with other types of institutions, we focus on bank flows because the richness of cross-country comparable bank balance sheet data allows us to compute specific types of flows and associate these directly with features of the balance sheets of the institutions intermediating the flows. Specifically, we use a novel data set for European countries' aggregate banking sector balance sheets. This data set is compiled by the Swiss National Bank in collaboration with central banks of participating European countries. It distinguishes between banks' domestic and foreign counterparties as well as positions in local and foreign currency, the latter being further divided into Swiss francs and other foreign currencies. We obtain cross border foreign currency flows by valuation adjusting the quarterly changes in outstanding positions using additional country specific data sources on the currency breakdown of positions in non-Swiss franc foreign currencies.

A remaining data challenge is the lack of information on off-balance sheet foreign currency exposures, which can be an important part of banks' total foreign currency exposures. We instead use on-balance sheet foreign currency exposure as a proxy, and control empirically for drivers of the use of off-balance sheet foreign currency instruments by including deviations from covered interest parity, as suggested by the model. This source of imprecision could attenuate our results. The results, however, confirm the main predictions of the model. The global risk factor is not significant on its own, but becomes significant when interacted with foreign currency exposure. We find that the effect is most pronounced, and very robust, in countries outside the euro area, while global factors do not significantly explain foreign currency funding flows in countries that use the euro. This difference could be related to differences in foreign currency hedging practises across the two country samples. We also find that the most consistently empirically relevant measure of the global financial factor is growth in US broker dealer leverage, as proposed notably in Adrian and Shin [2014]. Alternative measures often used in the literature, such as the VIX and measures of US financial conditions, are not significant in the sample that we consider.

Our model and empirical findings underline that global factors are not just indiscriminate push factors, and that both the size and sign of a country's capital flow sensitivity to global factors depends on institutional features associated with the set of financial institutions involved in intermediating a country's cross border flows. Specifically, our findings imply that currency mismatches in the balance sheets of a country's financial institutions may not only increase a country's vulnerability to capital flow volatility, but could directly influence the direction and intensity of the country's capital flows in the first place. More research is needed to establish the generality of this result for other types of flows and sets of countries.

The paper is structured as follows. Section 2 gives an overview of related literature. Section 3 presents the model and derives testable implications. The data and relevant stylized facts are presented in Section 4, which also presents the variables we consider and the econometric setup. Section 5 presents the econometric results, and the final Section concludes. Supporting materials are provided in the appendix.

2 Related literature

Our work ties to three broad streams of literature. The first is the analysis of the drivers of capital flows, and in particular, the role of foreign push factors versus domestic pull factors (Calvo et al. [1996], Forbes and Warnock [2012b], Fratzscher [2012], Ghosh et al. [2014], McQuade and Schmitz [2016]). This literature generally finds that push factors such as global financial and economic conditions play an important role in explaining cross border capital flows independently of country specific pull factors. Recent contributions find that the role of push factor is heterogeneous across categories of capital flows. Avdjiev et al. [2016c] find that the impact of global risk conditions has changed in recent years. Cerutti et al. [2015] shows that the impact of risk depends on the mix of foreign financial institutions intermediating capital flows, leading to cross country heterogeneity in the impact of push factors. We take a step further and focus on the role of *domestic* financial institutions. A clean distinction between push and pull factors may be misleading if country specific financial factors explain how global push factors affect a country's capital flows.

The second stream of related literature pertains to the international transmission of shocks through international bank linkages. Several papers stress global bank funding structures and networks as central in the cross border transmission of shocks (Takats [2010], Avdjiev et al. [2012], Bussiere et al. [2016], McCauley et al. [2015], Milesi-Ferretti and Tille [2011]). Claessens and van Horen [2015] point out that the structure of the international banking system has gone through substantial changes in the crisis, which can affect the transmission of shocks. Cetorelli and Goldberg [2011] document the transmission of shocks through cross-border bank lending and operations of banks' local affiliates. Cetorelli and Goldberg [2012] underline the role of banks' internal capital markets, and show that global banks' affiliates in more robust countries can be used as sources of funds for the parent in a crisis. A key aim in this literature is to assess how financial and monetary developments in global financial markets, or in the home country of the foreign funding currency, impact funding conditions in other countries (Bruno and Shin [2014], Cerutti [2015] and Cerutti et al. [2016]). A general finding is that global financial factors, including global financial sentiment typically captured by the VIX, and US monetary and financial conditions, drive bank funding costs in other countries. Avdjiev et al. [2016b] find that the role of the VIX in driving global flows has diminished, while the real exchange rate of the USD has gained in prominence as a driver, underlining possible structural changes in funding markets since the crisis (see also Bremus and Fratzscher [2015]). Our results suggest a complementary interpretation of a changing impact of global risk factors since the crisis, in that the response of bank capital flows to global financial factors may be conditional on the structure of bank balance sheets and their risk management behavior, which have changed.

The final line of research that we link to is the analysis of borrowing in foreign currencies. Foreign currency borrowing increased substantially before the crisis in some countries, notably in Eastern Europe where the issuance of foreign currency mortgages increased prior to the crisis, and dropped again after the crisis (Krogstrup and Tille [2017c], (Yesin [2013]). Foreign currency borrowing by nonfinancial firms also increased in some countries (Bruno and Shin [2015], Caballero et al. [2015]), and analysis of carry trades (Brunnermeier et al. [2009]). Borrowers may have been unaware of the full extent of the risks taken with such loans. Alternatively, taking foreign currency loans can translate into a schedule of payments for the borrower that is more favorable compared to a loan in domestic currency even when the full risk is internalized by the borrower (Dell'Ariccia et al. [2016]). Foreign currency borrowing has often been limited to a few key currencies, giving rise to currency networks in international banking activity (Avdjiev and Takats [2016]), the presence of which opens channels for across border transmission of monetary policy from the home countries of these key currencies (Takats and Temesvary [2016]). A recent line of research related to foreign currency borrowing focuses on the breakdown of covered interest parity. A firm can borrow in a foreign currency and lend in its domestic currency without incurring any exchange risk, if it also takes a position in the forward exchange rate markets. The covered interest parity condition implies that the two options carry the same cost, as otherwise there would be an opportunity for risk-free arbitrage. While covered interest parity conditions generally held empirically before the crisis, we have since seen sizable deviations that may reflect a limited ability of banks to take the leverage required to exploit the arbitrage conditions (see Du et al. [2017], Avdjiev et al. [2016a] and Borio et al. [2016]). This recent development motivates the inclusion of a forward currency contract, balance sheet costs of holding this contract, and deviations from covered interest parity in our analysis.

3 A model of wholesale bank funding

This section presents a simple partial equilibrium model of a financial institution's funding portfolio decision, and how it reacts to shocks in the short term, depending on the structure of the balance sheet and risk preferences. The setup is a simplified version of the model developed in Krogstrup and Tille [2017b]. Below, we refer to the financial institution as a bank in order to match it with the subsequent empirical analysis of bank balance sheet data, but the model is general enough to also characterize other types of financial institutions.

The model relates changes in global risk conditions to the currency composition of the wholesale funding portfolio of the bank in the short term. Wholesale funding is net of wholesale lending in our model, the underlying assumption being that the bank can place wholesale lending in the interbank market at the same conditions as it can obtain wholesale funding in that market. We focus on the currency split of net wholesale funding because foreign currency wholesale funding is likely to capture the majority of cross border foreign currency flows emanating from banks in the short term. Banks do maturity transformation, and wholesale funding is traditionally of shorter duration and hence the component of the balance sheet that banks can most rapidly adjust. By contrast, changing the composition of loans or deposits will usually take longer time and is less directly under the control of banks, as these balance sheet items are often of longer duration and can respond autonomously to changes in costumer demand for credit and deposits.[2] Below, we derive the determinants of the bank's choice of currency composition of wholesale funding, taking the currency composition of loans and other liabilities as given or predetermined. We selectively present only the main elements of the model that will help illustrate the mechanisms that we are interested in. A more complete presentation of the model is available in Appendix A.

3.1 Main building blocks

Figure 3.1 is a snapshot of the model's bank balance sheet. There is only one foreign currency, which we think of as the USD. The exchange rate between the domestic and the foreign currency, in terms of units of local currency per unit of foreign currency, is denoted by S. The bank's assets are loans, C, issued either in domestic or in foreign currency. Its liabilities include domestic and foreign currency deposits and wholesale funding, D and F, and equity issued in domestic currency, K.[3] Wholesale funding figures on the liabilities side of the balance sheet, and since it is net of wholesale lending, it can turn negative. In addition to

[2] See Christensen and Krogstrup [2016] for an example of how bank deposits can respond autonomously to the portfolio choice of a bank's customers, and Choi and Choi [2016] for how banks tend to adjust wholesale funding to shocks in deposit funding empirically.

[3] No equity is issued in foreign currency.

Assets		Liabilities	
Loans:	$C^{dom} + SC^{for}$	Deposits:	$D^{dom} + SD^{for}$
		Wholesale Funds:	$F^{dom} + SF^{for} = F$
		Equity:	K

Figure 1: **The bank's balance sheet structure**
S is the spot exchange rate (domestic per foreign currency units). Superscripts *dom* and *for* denote currency of issuance (domestic or foreign currency). C is loans and D is deposits, divided on currency of issuance and exogenous and fixed in the currency of issuance. K is equity and is predetermined. F is total net wholesale funding and is residually determined, given the other exogenous and predetermined balance sheet items. The currency mix of wholesale funding is adjustable. Beyond the balance sheet, the bank also has access to an off-balance sheet currency forward market.

the balance sheet items in Figure 3.1, the bank can take positions in the currency forward market, which we describe further below.

The model covers two periods, t and $t+1$. The exchange rate in period t is given by $S_t = S_0 \exp[s_t]$, where S_0 refers to a long-term average or normal level, the meaning of which is discussed in more detail in Section 3.2.3. The exchange rate in period $t+1$ is $S_{t+1} = S_0 \exp[s_t + s_{t+1}]$.[4] The value of loans issued in domestic currency, C^{dom}, is assumed to be constant in terms of domestic currency in both periods.[5] Similarly, the value of loans denominated in foreign currency, C^{for}, is fixed in foreign currency. Deposits are modelled similarly to loans. The value of domestic deposits is D^{dom} and the foreign currency value of deposits denominated in foreign currency is D^{for}. The bank cannot adjust the amount of loans or deposits.[6]

As loans and deposits are exogenous, and equity is predetermined and cannot be actively changed by the bank, the total value of the bank's wholesale funding in period t is also predetermined. The currency composition of the wholesale funding portfolio, however, can be adjusted by the bank. We denote domestic currency wholesale funding in period t by F^{dom}. The gross cost to the bank of acquiring this type of funding is $\exp\left[r_{t+1}^{F,dom}\right]$, so that the bank's associated liability amounts to $F^{dom}\exp\left[r_{t+1}^{F,dom}\right]$ in period $t+1$. Similarly, the foreign currency value of wholesale funding in foreign currency is F^{for}, and the related cost is $\exp\left[r_{t+1}^{F,for}\right]$.[7] Taking into account the cost of foreign currency funding in terms of domestic currency due to exchange rate changes, the cost of on-balance sheet foreign currency wholesale funding is $\exp\left[r_{t+1}^{F,for} + s_{t+1}\right]$.

[4]The appendix provides a more detailed description of s_t and s_{t+1}.

[5]Allowing for shocks to the return on loans does not alter our results. See Krogstrup and Tille [2017b] for a more general version of the model including shocks to interest income on loans and deposits.

[6]This assumption is relaxed in other contributions. For instance Ivashina and Stein [2015] consider a similar model where the lending currency mix is endogenous to the bank's decisions, in order to study how shocks to the funding currency mix translate into changes in the lending currency mix.

[7]The appendix describes $r_{t+1}^{F,dom}$ and $r_{t+1}^{F,for}$ in more details.

Banks also participate in the foreign currency swap market (Fender and McGuire [2010]). We include this dimension through a forward exchange rate contract. The contract pays off the forward rate $T_{t+1} = S_0 \exp[t_{t+1}]$ units of domestic currency per foreign currency in period $t+1$, which is known in period t. The realized cost in period $t+1$ of this covered foreign funding through the swap market is thus $\exp\left[r_{t+1}^{F,for} + t_{t+1} - s_t\right]$. As all terms are fully known in period t, the covered foreign currency funding position entails no risk, and it is therefore directly comparable to domestic currency funding in its risk profile. If $t_{t+1} - s_t < r_{t+1}^{F,dom} - r_{t+1}^{F,for}$, the cost of swapped funding is lower than the cost of domestic wholesale funding. In the absence of other costs, this implies an unlimited risk-free arbitrage opportunity, and the only equilibrium would be for the cost of domestic and covered foreign funding sources to be equalized. There is, however, occasionally large and persistent deviations from covered interest parity, in particular since the global financial crisis. The fact that banks do not take unlimited positions suggests the presence of additional costs in foreign currency swap markets (Ivashina and Stein [2015]). Such costs could be time varying risk premiums of specific financial institutions or sectors, constraints on the balance sheet capacity of swap market participants, and constraints on counterparty risk taking (Du et al. [2017], Borio et al. [2016], Avdjiev et al. [2016b]). We include such costs in the model by assuming that positions in the forward contract entail a balance sheet cost which is quadratic in the amount of positions the bank takes. In a fully specified global equilibrium model, the presence of such costs would be the driver of deviations from covered interest parity in the first place. In our partial equilibrium model, however, we assume that each bank takes the deviation from covered interest parity as given.

The presence of risk-free arbitrage through covered foreign currency borrowing, with a marginally increasing balance sheet cost associated with it, gives banks an incentive to engage in covered foreign currency borrowing up to the point where costs outweigh the risk-free benefit. This part of foreign currency funding is driven purely by the risk free return and the balance sheet costs, and not by a risk-return trade-off or a desire to change exposure to risk. Risk exposure is fully managed in the uncovered foreign currency funding market. As we only observe total foreign currency funding in the data, and not covered and uncovered foreign currency funding individually, it is important to include the drivers of both types of funding to allow us to take the implications of the model to the data.

The total payoff in period $t+1$ of buying G units of the forward contract is:

$$G\left(T_{t+1} - S_{t+1}\right) - \frac{\alpha_{t+1}}{2}\left(G\right)^2$$

where the balance sheet cost term α_{t+1} is presented in more details in the appendix.

3.2 Solution of the model

3.2.1 Optimality conditions

The bank is initially endowed with an equity position K_t in domestic currency:

$$K_t = C^{dom} - D^{dom} - F^{dom} + S_t \left[C^{for} - D^{for} - F^{for}\right]$$

We assume that the bank cannot raise new equity within the two periods. The bank's equity in period $t+1$, K_{t+1}, then reflects the overall changes in the values of loans, deposits, wholesale funding, and forward exchange rate contract payoff:

$$\begin{aligned} K_{t+1} &= C^{dom} - D^{dom} - F^{dom} \exp\left[r^{F,dom}_{t+1}\right] \\ &+ S_t \exp\left[s_{t+1}\right]\left[C^{for} - D^{for} - F^{for} \exp\left[r^{F,for}_{t+1}\right]\right] \\ &+ G\left(T_{t+1} - S_{t+1}\right) - \frac{\alpha_{t+1}}{2}\left(G\right)^2 \end{aligned}$$

A bank will choose its wholesale funding currency mix—and hence its total exposure to currency risk—according to the risk management framework employed, such as a Value-At-Risk framework as discussed in Adrian and Shin [2014], in addition to regulatory constraints on risk taking and other factors. It is out of the scope of this paper to model such factors in a complete sense. Instead, we follow the literature and note that the presence of risk, moral hazard and regulatory rules can imply a convex payoff schedule for the bank (e.g. Adrian and Duarte [2016], Nuno and Thomas [2017]). As an approximation, we assume that the bank maximizes a CRRA expected utility function of equity in the final period:

$$U = \frac{1}{1-\gamma} E_t \left(K_{t+1}\right)^{1-\gamma}$$

The optimization takes place subject to the constraint that overall wholesale funding is given initially. Combining the first-order conditions with respect to the wholesale funding in domestic and foreign currency, we get the standard result that the bank will choose uncovered foreign currency funding to the point where the expected discounted excess returns between the domestic and foreign currency funding are zero:

$$0 = E\left(K_{t+1}\right)^{-\gamma}\left[\exp\left[s_{t+1} + r^{F,for}_{t+1}\right] - \exp\left[r^{F,dom}_{t+1}\right]\right] \tag{1}$$

The first-order conditions with respect to the holdings of the forward contract imply that the bank will choose covered foreign currency funding to the point where the expected discounted excess returns between the forward and spot exchange rate offset the expected discounted marginal cost of holding the contract:

$$0 = E\left(K_{t+1}\right)^{-\gamma}\left(T_{t+1} - S_{t+1} - \alpha_{t+1} G\right) \tag{2}$$

The solution boils down to the two optimality conditions (1) and (2). As these are highly non-linear, we compute the solution by taking a Taylor expansion.

3.2.2 Orders of the solution

The approximation of (1) and (2) requires a careful treatment of the various components of shifts in the variables. We follow Tille and van Wincoop [2014] and express all variables in terms of components of various orders. Zero-order components are not proportional to innovations in the exchange rate (shocks). In short, first-order components are linearly proportional to such innovations while second-order components are linearly proportional to the square products of the innovations. Third-order components are linearly proportional to the cubic products of innovations, and so on.

Using this terminology, we solve for the funding portfolio at two levels. The first level reflects the baseline environment faced by the bank, which we think of as the average or normal situation or the long-term trend, with normal levels of risk. The environment consists of exogenous drivers of loans and deposits, interest rates, expected exchange rate movements, and the moments of baseline shocks (i.e. risk). This baseline environment leads to the zero-order component of the funding portfolio chosen by the bank, around which we do our Taylor expansion. The second level reflects the "shifted" environment, where the values of the environment variables differ from the baseline ones. This shifted environment is the deviation from baseline and allows us to assess the impact of, for instance, an unusually large amount of loans, an unusually large expected exchange rate movement, or an unusual amount of risk. The shifted environment is associated with the first-order component of the funding portfolio, that is, how the portfolio is adjusted in response to shifts in the environment away from baseline.

3.2.3 Baseline solution (zero-order)

It is useful to first define the deviations from uncovered and covered interest parity:

$$uip = r_{t+1}^{F,for} + E_t s_{t+1} - r_{t+1}^{F,dom} \quad ; \quad cip = r_{t+1}^{F,for} + p_{t+1} + E_t s_{t+1} - r_{t+1}^{F,dom}$$

where p_{t+1} is the forward premium.[8] Positive values indicate that funding in foreign currency is more expensive than funding in the domestic currency. This can reflect interest rate spreads, expected exchange rate movements, and the expected forward premium (for the covered interest parity).

We first solve for the baseline wholesale funding positions and forward contract holdings. Denote the (zero-order) position in wholesale foreign currency funding by F_0^{for}, and the holdings of the forward contract by G_0, and denote the second-order components of the deviations from uncovered and covered interest parity by $uip_{baseline}$ and $cip_{baseline}$ respectively. Further, define two measures of the net foreign currency exposure in the baseline solution:

$$Net_0^{OnB} = S_0 \left[C_0^{for} - D_0^{for} - F_0^{for} \right] \quad ; \quad Net_0^{tot} = Net_0^{OnB} - S_0 G_0 \tag{3}$$

where C_0^{for} and D_0^{for} are the (zero-order) values of foreign currency loans and deposits in the baseline environment, and S_0 is the (zero-order) exchange rate. Net_0^{OnB} measures on-balance sheet foreign currency exposure.[9] This is the measure that we focus on in the empirical application, as it is observed in the data. A positive value indicates that the bank is long in foreign currency on its balance sheet, as the value of its total foreign currency loans exceeds the values of its total foreign currency deposits and wholesale funding. This measure does not take into account the part of foreign currency lending and funding that is covered in the off-balance sheet forward market. Net_0^{tot} is instead the broad measure that also includes the exposure through the forward exchange rate contract.

Using this notation, the baseline solution is:

$$G_0 = \frac{cip_{baseline}}{\alpha_{baseline}} \quad ; \quad Net_0^{tot} = K_0 \frac{uip_{baseline}}{\gamma_0 \sigma_{fx}^2} \tag{4}$$

where $\alpha_{baseline}$ is the second-order term of the cost α of holding the forward contract, K_0 is the zero-order component of equity, γ_0 is the (zero-order) coefficient of risk aversion in the baseline, and σ_{fx}^2 is the second-order variance of exchange rate shocks.

The position in the forward contract, G_0, reflects the deviation from covered interest parity and the marginal cost of holding the contract. It is unaffected by risk aversion or risk, because the forward contract in combination with spot funding positions offers risk-free arbitrage, which the bank will exploit fully up until the cost of buying more contracts outweigh the risk-free returns.

Given G_0, F_0^{for} follows from Net_0^{tot}. The total exchange rate exposure that the bank

[8] *uip* and *cip* are presented in more details in the appendix.

[9] In the general case, this measure of foreign currency exposure would include the cross interest on the three components of the term. These are equal to one in baseline, however, and hence do not figure here.

chooses reflects two primary considerations. First, the bank chooses the currency mix of its wholesale funding to absorb exchange rate exposure in the rest of its portfolio. A full hedging corresponds to $Net_0^{tot} = 0$. Second, deviations from *uip* imply that there is an expected cost advantage or disadvantage to using funding in foreign currency, which the bank will want to take advantage off up until the point where the additional risk introduced by using foreign currency funding becomes undesirable for the bank to hold given the associated risk, and given the bank's risk aversion. This leads to a trade-off between taking advantage of the expected spread in funding costs and the hedging of the associated risk. When the cost of funding in foreign currency is higher, the bank will want to rely less on funding in that currency (or will want to lend more in that currency), which results in a higher net positive exposure to exchange rate risk (it gets less short, or longer, in foreign currency). The magnitude of this effect is inversely proportional to baseline exchange rate risk and risk aversion: more risk (a higher σ_{fx}^2) and higher risk aversion (a higher γ_0) lower the absolute foreign currency exposure for given funding costs.

Finally, note that expressions (3) and (4) illustrate that on-balance sheet and total foreign currency exposures are linked through the deviation from covered interest parity in baseline. The intuition is that when the deviation from covered interest parity is greater, there is more incentive to use the forward currency market for arbitrage, and therefore a greater distance between on balance sheet and off balance sheet foreign currency exposure. We use this observation to estimate total currency exposure for a robustness test, as described in Section 4.2.2.

3.2.4 Solution for deviations from baseline (first-order)

We now derive the solution for how foreign currency funding and forward positions react to changes in the environment. Separate the wholesale funding position into zero-order terms that reflect the baseline environment and first-order terms that reflect changes from that environment:

$$F_t^{dom} = F^{dom} - F_0^{dom} \quad ; \quad F_t^{for} = F^{for} - F_0^{for}$$

where F_0^{dom} and F_0^{for} are the zero-order components given by expression (4), and F_t^{dom} and F_t^{for} are the first-order components, i.e. deviations from baseline. The position in the forward contract, loans, and deposits are written similarly.[10,11] We denote shifts in the

[10]Specifically: $G = G_0 + G_t$, $C^{dom} = C_0^{dom} + C_t^{dom}$, $C^{for} = C_0^{for} + C_t^{for}$, $D^{dom} = D_0^{dom} + D_t^{dom}$ and $D^{for} = D_0^{for} + D_t^{for}$.

[11]The solution for F_t^{for} and G_t relies on the baseline solution derived above and the third-order elements of (13) and (14).

deviations from uncovered and covered interest parity away from baseline by $uip_{deviation}$ and $cip_{deviation}$ respectively, with the exact expressions given in the appendix. Positive values indicate that funding in the foreign currency is more expensive, relative to its cost differential in the baseline environment.

Using these expressions, the holdings of the forward contract reflect the deviation from covered interest parity and the hedging cost (all relative to their baseline values):

$$G_t = \frac{cip_{deviation}}{\alpha_{baseline}} - G_0 \frac{\alpha_{deviation}}{\alpha_{baseline}} \tag{5}$$

where $\alpha_{deviation}$ is the third-order component of the cost α, and reflects how the cost of holding the forward contract differs from the baseline environment ($\alpha_{deviation} > 0$ indicates that the cost is higher than usual).

The first-order solution for total foreign currency funding (including the covered as well as uncovered variety) is given by:

$$\begin{aligned} S_0 F_t^{for} = {} & Net_0^{tot} \left(\gamma_t + \nu_{t+1}^{\sigma} \right) + Net_0^{tot} s_t \\ & - Net_0^{OnB} \frac{Net_0^{tot}}{K_0} s_t + S_0 C_t^{for} - S_0 D_t^{for} \\ & - \frac{K_0}{\gamma_0} \frac{uip_{deviation}}{\sigma_{fx}^2} - S_0 \left(\frac{cip_{deviation}}{\alpha_{baseline}} - G_0 \frac{\alpha_{deviation}}{\alpha_{baseline}} \right) \end{aligned} \tag{6}$$

The first-order solution (6) is expressed in terms of deviations from baseline values, for a given exchange rate S_0 (i.e. deviations due to valuation effects of exchange rate shifts away from baseline are not included). The funding position in foreign currency can exceed its baseline value ($F_t^{for} > 0$, meaning a larger foreign currency liability position or a smaller foreign currency asset position) for a number of reasons.

The first term in the first line in (6) is the focus of this paper. It confirms that the effect of risk and risk aversion on foreign funding depends qualitatively on baseline balance sheet features. $\nu_{t+1}^{\sigma} > 0$, which captures shifts in exchange rate variance away from baseline, indicates that risk is elevated relative to baseline, while $\gamma_t > 0$ reflects an environment where risk aversion is elevated. Higher risk and/or higher risk aversion leads the bank to reduce its exposure to exchange rate risk. A key feature is that the impact on foreign currency funding depends on the pre-existing net foreign currency exposure. If the bank is long in foreign currency ($Net_0^{tot} > 0$) in the baseline, reducing the risk exposure requires the bank to increase its foreign currency wholesale funding. By contrast, foreign currency wholesale funding is reduced if the baseline net position is short ($Net_0^{tot} < 0$). This is the central result that we are testing in this paper.

The second term in the first line contains a standard portfolio rebalancing result as also found in the previous literature (e.g. Hau and Rey [2008]). Foreign wholesale funding adjusts to rebalance the direct impact of the exchange rate on the currency exposure through valuation effects. s_t indicates how the initial exchange rate differs from the baseline value, with $s_t > 0$ indicating that the foreign currency is stronger than in the baseline environment. If the bank holds a long foreign currency position in the baseline ($Net_0^{tot} > 0$), the stronger foreign currency raises the domestic currency value of the net position. This is offset by additional funding in foreign currency.

The first term in the second line also contains the exchange rate in period t, and captures a risk-taking channel arising from balance sheet valuation gains and losses akin to the risk taking channel of international monetary policy transmission as described in Bruno and Shin [2013]. Consider a situation where the bank has a long foreign currency position on balance sheet in the baseline ($Net_0^{OnB} > 0$).[12] A strengthening of the foreign currency in the first period ($s_t > 0$) generates a capital gain for the bank (before the forward contract kicks in), and higher equity in period $t+1$. All else equal, this puts the bank on a part of its utility where marginal utility is reduced. The bank is thus willing to take on more risk. If the baseline foreign currency exposure is long ($Net_0^{tot} > 0$), taking extra risk is achieved through a reduction of foreign currency funding ($F_t^{for} < 0$). Our model thus shows that the impact of the risk taking channel depends on the initial net foreign currency exposure. The channel is distinct from the direct impact of exchange rate exposure presented in the first line. Notice that the impact of this term on wholesale foreign currency funding also depends on the equity position of the bank (K_0), which we do not observe empirically.

The last two terms in the second line capture the effect of deviations in foreign currency loans and deposits from baseline on wholesale foreign currency funding. The terms C_t^{for} and D_t^{for} indicate if the value of loans and deposits denominated in foreign currency deviate from the baseline environment. The bank's long foreign exchange position is increased when there are more loans ($C_t^{for} > 0$) or fewer deposits ($D_t^{for} < 0$) denominated in foreign currency, and this is offset by higher foreign currency wholesale funding.

The third line in (6) captures the drivers of wholesale foreign currency funding related to interest rates. Uncovered funding will respond directly to changes in the deviation from uncovered interest parity $uip_{deviation} > 0$, following expression (4). Covered funding will be unresponsive to changes in risk factors, as also illustrated by expression (4), but will instead

[12] The fact that it is the on-balance sheet exposure that matters to the valuation again is an artifact of our modeling choices, and has to do with the way we model the forward rate as a function of the baseline spot exchange rate and not the shifted one.

be driven by the excess risk-free return that can be made on covered foreign currency funding relative to domestic currency funding (the deviations from covered interest parity) and the balance sheet costs associated with positions in the forward contract. If the deviation from covered interest parity increases ($cip_{deviation} > 0$) or the cost of holding the forward contract goes up ($\alpha_{deviation} > 0$), covered foreign currency wholesale funding drops.

The third line also makes clear that the response of total foreign wholesale funding to funding costs depends on baseline variables specific to the bank (balance sheet structure and behavior), suggesting that these terms should enter a panel regression allowing for the parameter estimates to vary across countries. We do this in robustness checks.

3.2.5 An empirical specification

To derive an empirical estimating equation from expression (6), we first divide all terms in (6) by the total domestic currency value of the bank's balance sheets in baseline A_0, to have ratios that are comparable across countries. We also take first differences, which cancels out baseline values in many, but not all, terms. This is an advantage, as estimating the baseline steady state values is problematic with our relatively short sample. These two steps yield the following expression:

$$\begin{aligned} \frac{S_{0,i} \cdot dF_{t,i}^{for}}{A_{0,i}} &= Net_i \left(d\gamma_{t,i} + d\nu_{t+1,i}^{\sigma} \right) + Net_i ds_{t,i} - \frac{A_{0,i}}{K_{0,i}} \left(Net_i \right)^2 ds_{t,i} \\ &\quad + \frac{S_{0,i} \cdot dC_{t,i}^{for}}{A_{0,i}} - \frac{S_{0,i} \cdot dD_{t,i}^{for}}{A_{0,i}} \\ &\quad - \frac{K_{0,i}}{A_{0,i}\gamma_{0,i}} \frac{duip_{deviation,i}}{\sigma_{fx,i}^2} - \frac{S_{0,i}}{A_{0,i}\kappa_{t+1}^V} \left(dcip_{deviation,i} + G_{0,i} d\alpha_{deviation} \right) \end{aligned} \tag{7}$$

where variables without time subscript refer to country specific baseline values, and variables without country subscript refer to global time-varying variables. Net_i is an empirical measure of net foreign currency exposure, the nature of which we discuss in more detail in Section 4.2.2.

We then make a series of simplifying assumptions and adjustments. First, because we cannot distinguish between risk and risk aversion empirically, we test for both jointly, and distinguish instead between a global financial factor (GF) and a local one (LF). The GF captures risk and risk aversion related to global conditions in bank funding markets, as in Forbes and Warnock [2012a] and Rey [2015], while LF captures country specific foreign currency risk and risk aversion. Higher values of GF and LF denote higher risk or higher risk aversion. Following the theoretical results, we include these risk factors on their own, and interacted with net currency exposure, in the estimating equation.

Second, the model indicates that the parameters for the risk taking channel of exchange rate valuation effects and those of *uip* and *cip* depend on country specific features (such as bank equity and country specific average risk factors). We include them with joint parameter estimates in the baseline specification to simplify, but check robustness to allowing the parameter estimates to vary across countries.

Third, the cost of engaging in foreign exchange swap contracts, α, is not empirically observable and is hence not included in the regressions. α is likely to be correlated with deviations from CIP, as in Ivashina and Stein [2015]. If indeed we were to allow α to be proportional to *cip* in the model, the two terms would collapse into one with a different parameter. We keep this interpretation of what *cip* is capturing in the regression in mind when interpreting the results. Moreover, to the extent that the balance sheet cost is common across countries, we can capture it with time fixed effects, which pick up all factors that are common across countries but vary over time. As a robustness text, we hence also run the regressions with time fixed effects instead of the global factor on its own, but still including the interaction between the global factor and net currency exposure.

Finally, we add country fixed effects to capture all time invariant country specific factors affecting foreign currency funding decisions. Taking into account all these assumptions and adjustments yields our main empirical estimating equation:

$$\begin{aligned} d\tilde{F}^{for}_{t,i} \quad = \quad & \beta_0 + \beta_1 \cdot dlog\left(GF_{t-1}\right) + \beta_2 \cdot Net_i \cdot dlog\left(GF_{t-1}\right) \\ & + \beta_3 \cdot dlog\left(LF_{t-1}\right) + \beta_4 \cdot Net_i \cdot dlog\left(LF_{t-1}\right) \\ & + \beta_5 \cdot dlog\left(S_{i,t-1}\right) + \beta_6 Net_i \cdot dlog\left(S_{i,t-1}\right) + \beta_7 \cdot Net_i^2 \cdot dlog\left(S_{i,t-1}\right) \\ & + \beta_8 \cdot Net_i + \beta_9 \cdot Net_i^2 \\ & + \beta_{10} \cdot d\tilde{C}^{for}_{t,i} + \beta_{11} \cdot d\tilde{D}^{for}_{t,i} \\ & + \beta_{12} \cdot duip_{i,t-1} + \beta_{13} \cdot dcip_{i,t-1} \\ & + \mu_i + \epsilon_{i,t} \end{aligned} \tag{8}$$

where $d\tilde{F}^{for}_{t,i} = S_{i,t-1} dF^{for}_{t,i} / A_{i,t}$ is the valuation adjusted change in net foreign currency wholesale funding as a share of total bank assets, $d\tilde{C}^{for}_{t,i} = S_{i,t-1} dC^{for}_{t,i} / A_{i,t}$ is the valuation adjusted change in foreign currency assets net of wholesale assets as a share of total bank assets, and $d\tilde{D}^{for}_{t,i} = S_{i,t-1} dD^{for}_{t,i} / A_{i,t}$ is the valuation adjusted change in foreign currency liabilities net of wholesale liabilities as a share of total bank assets.

The model analyzes the bank's demand for foreign currency wholesale funding, taking the supply side as well as domestic and global prices of funding as exogenous. It is possible that changes in demand also affect prices and supply, giving rise to endogeneity, a common problem in the literature. We follow the standard approach of lagging all explanatory variables by one quarter (e.g. Cerutti et al. [2016]). Given that there is some persistence in bank balance sheet dynamics and in the explanatory variables, one should bear in mind that lagging may not fully alleviate endogeneity concerns.

The model implies that β_1, β_2, β_4, β_6 and β_{10} are positive, and β_7, β_{11}, β_{12} and β_{13} are negative. There are no priors for the signs of the remaining parameter estimates.

4 The data

4.1 Dependent variable

For bank balance sheet data, we rely on the Swiss Franc Lending Monitor (SFLM) database. This database is maintained by the Swiss National Bank and contains data from 20 participating European central banks.[13] We include the 16 of these countries, that have sufficiently complete data, in our sample.[14] Most, but not all, of the data included in the SFLM are publicly available through national data sources. The SFLM was initiated in 2009, but some participating countries provide data for earlier quarters as well, and we use an unbalanced sample that starts in the first quarter of 2007.[15] This allows us to cover a part of the financial crisis period. We check robustness throughout to excluding data prior to Q2 2009, which turns out to be important. The SFLM contains quarterly data on various components of resident banks' balance sheet positions, aggregated to the country level across all banks residing in the country.[16] All balance sheet positions are divided on currency of issuance. Specifically, positions are divided on those issued in local currency, those issued in Swiss francs, and those issued in other foreign currencies than the Swiss franc. These other foreign currency positions are not broken further down into individual currencies. Assets are divided on lending and other assets, while liability positions are divided on deposits (including repo and interbank borrowing), own securities issuance and other liabilities. Lending and deposits are further

[13] Austria, Bulgaria, Czech Republic, Croatia, Denmark, Estonia, France, Germany, Greece, Hungary, Iceland, Italy, Latvia, Luxembourg, Poland, Romania, Serbia, Slovenia, Slovakia, and the United Kingdom.

[14] We exclude Iceland and France due to insufficient data coverage. Luxembourg is excluded as an outlier, and Poland is excluded due to incomplete data on the asset side of the balance sheet. We include data for Estonia from 2011 when it joined the euro. Estonia is hence considered a euro area country. In contrast, we include data for Latvia only until 2014, when it joined the euro, and we hence consider Latvia a non-euro area country in this sample.

[15] The individual country charts in the appendix reflect the period covered for each country.

[16] The data thus includes subsidiaries of foreign banks, but not foreign bank branches. Subsidiaries of foreign banks, especially European ones, account for a very large share of the market, particularly in some Eastern European countries.

divided on resident banks and non-banks, and non-resident banks and non-banks.[17] The data structure is comparable in structure to the BIS locational banking statistics, but with a different country coverage. In particular, the division of bank balance sheets on currencies in the SFLM covers a broader set of European countries than the locational banking statistics, and in particular, it includes eastern European countries.

Our dependent variable is the change in net wholesale funding in foreign currency at constant exchange rates, as a ratio to total bank assets.[18] We measure foreign currency wholesale funding as the difference between foreign currency liabilities to non-resident bank counterparties, minus foreign currency denominated claims on non-resident bank counterparties. Including non-bank foreign claims and liabilities does not affect the results, as these positions are relatively small. As the SFLM quotes the value of all positions in domestic currency equivalents, we adjust for the direct valuation impact of exchange rate movements, as these affect the domestic currency value of a position issued in foreign currency. This is easily done for positions in Swiss francs, which are quoted explicitly in the SFLM. The adjustment is more challenging for other foreign currency positions, for which we rely on country specific data sources for the currency breakdown. The steps and the sources used to valuation adjust positions are described Appendix C. A similar adjustment is made when computing the flows of loans and non-wholesale liabilities denominated in foreign currencies.

Appendix E contains plots of the resulting net cross-border funding flows in foreign currency to bank counterparties as well as cross border flows to all counterparties and in all currencies for each of the sample countries. We observe substantial variation across countries and time. A pattern of particular interest is that foreign currency bank flows are of smaller magnitude for euro area countries than for other countries. There is much less heterogeneity in overall flows (including the ones in domestic currency). This reflects that cross border flows in euro countries are to a larger extent denominated in euros. We thus carry out all regressions splitting the sample into euro and non-euro area countries, a distinction that turns out to be important.

4.2 Explanatory variables

4.2.1 Risk factors

The main explanatory variables of interest are the global and local factors capturing risk and risk aversion. The literature proposes a host of different measures of global risk factors.

[17] The data does not divide positions with foreign bank counterparties on positions vis-a-vis a foreign parent bank and positions vis-a-vis an unrelated foreign bank.

[18] To focus on changes in positions between the domestic banking sector and the rest of the economy, we exclude domestic interbank positions from total bank assets.

We use quarterly growth in US broker dealer leverage, following Adrian et al. [2014], as the baseline global risk factor. Higher leverage growth among US broker dealers is associated with lower global risk aversion and higher liquidity within global wholesale funding markets. This global risk factor measure is likely to be particularly relevant for international banking flows, and this is indeed what we confirm in our empirical analysis. We multiply broker dealer leverage growth by -1 so that an increase denotes a higher level of risk aversion or more restrictive global financial conditions. We refer to this measure as *gbdl* in the following. We also consider other measures used in the literature, such as the log of the VIX (Forbes and Warnock [2012a], Rey [2015], Goldberg and Krogstrup [2016]), referred to as *lvix* in the following, and different measures of US financial and monetary conditions, further described in Section 5.3. We show that these alternative measures are less empirically relevant as drivers of foreign currency wholesale funding in our sample. Figure 2 shows how *gbdl* and *lvix* comove in the quarterly data, but not perfectly.

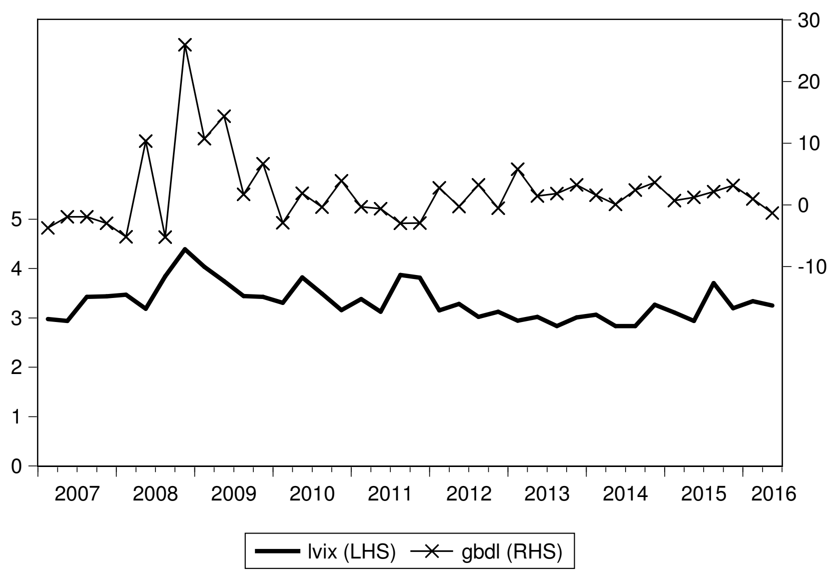


Figure 2: **Empirical measures of global risk factors**
$GBDL$ is the quarterly growth in US broker dealer leverage multiplied by minus one. $lvix$ is the log of the highest realized value of daily realizations of the VIX over the quarter. See Appendix B for sources.

We do not have similar proxies for the local risk factors for all sample countries, and rely instead on the realized volatility of the local currency against the US dollar as a proxy.

4.2.2 Net foreign currency exposure

To test the hypothesis that net foreign currency exposure determines how banks respond to changes in global risk conditions, we need a measure of banks' currency exposure. The size and sign of this exposure is driven by deviations from *uip* as well as initial equity, average riskiness and risk preferences, according to expression (4). As the levels of these variables are not observable, we instead seek to measure foreign currency exposure directly.[19] The theoretical treatment in Section 3 suggests that it is the total currency exposure, including off balance sheet positions, which matters, but the SFLM does not report off-balance sheet exposures, and we are not aware of other sources of data that do so consistently across countries and time. Instead, we approximate the exposure to foreign currency by the on-balance sheet foreign currency mismatch, which is directly observable in the SFLM. Specifically, we measure Net_i in expression (8) as foreign currency assets minus foreign currency liabilities, divided by total bank assets.[20] Net_i can conceivably range from -1 (if all liabilities and no assets are in foreign currency) to 1 (if all assets but no liabilities are in foreign currency). A positive value indicates that the banking sector of country i has a long foreign currency exposure on its balance sheet. Figure 3 depicts country specific sample average foreign currency exposures for each country. Figures 9 to 11 in Appendix E illustrate the variation over time in Net_i within each of the sample countries. As time variation is substantial, we rely on the lagged Net_i for the interaction term in the regression, instead of using the country sample averages.[21]

The net on balance sheet exposure is composed of the exposure within non-wholesale funding positions and the exposure within wholesale positions. Our model illustrated that the bank uses the currency mix of the adjustable wholesale funding to redress excessive foreign currency exposures within the parts of its balance sheet that it cannot adjust. The net currency exposures in our data set are consistent with this use of wholesale funding. This is illustrated by Figure 4, which contrasts the currency exposure in wholesale funding with the exposure in the other components of the balance sheet. The country-specific average exposure excluding net wholesale funding is shown on the horizontal axis, while the exposure in the wholesale funding position is shown on the vertical axis. If banks used wholesale funding in foreign currency to fully offset their exposure in the other positions of the balance sheet, the dots would line up on the negative 45 degrees line. While this is not exactly the case, we observe a clear negative association, suggesting that banks respond to the foreign cur-

[19] In robustness tests using the level of deviations from *uip* unadjusted for equity or risk as a proxy for net foreign currency exposure, we get very similar results. Not shown, but results are available upon request.

[20] Total bank assets exclude domestic interbank positions. Austria, Denmark and the Czech Republic do not report other assets and liabilities. For these countries, we instead proxy the foreign currency mismatch by the mismatch reflected in total lending and total deposits only.

[21] Sample average would be closer to theory, but our sample does not allow us to reasonably assess long-term underlying structural values

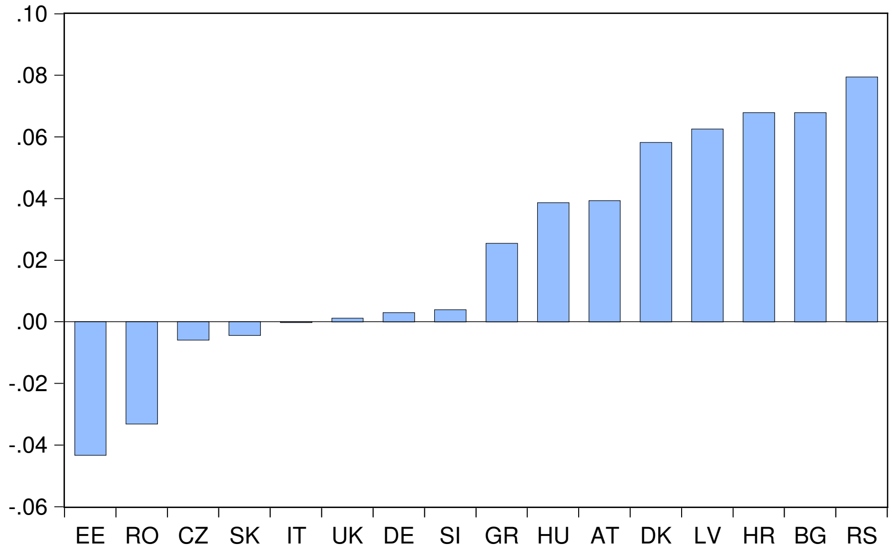


Figure 3: **Average foreign currency mismatch**
Averages for 2007Q1-2016Q2. Foreign currency mismatch is computed as foreign currency assets less foreign currency liabilities divided by total bank assets net of domestic interbank positions. Source: SFLM (Swiss National Bank).

rency exposure in their non-wholesale portfolio by taking offsetting positions in the wholesale funding market.

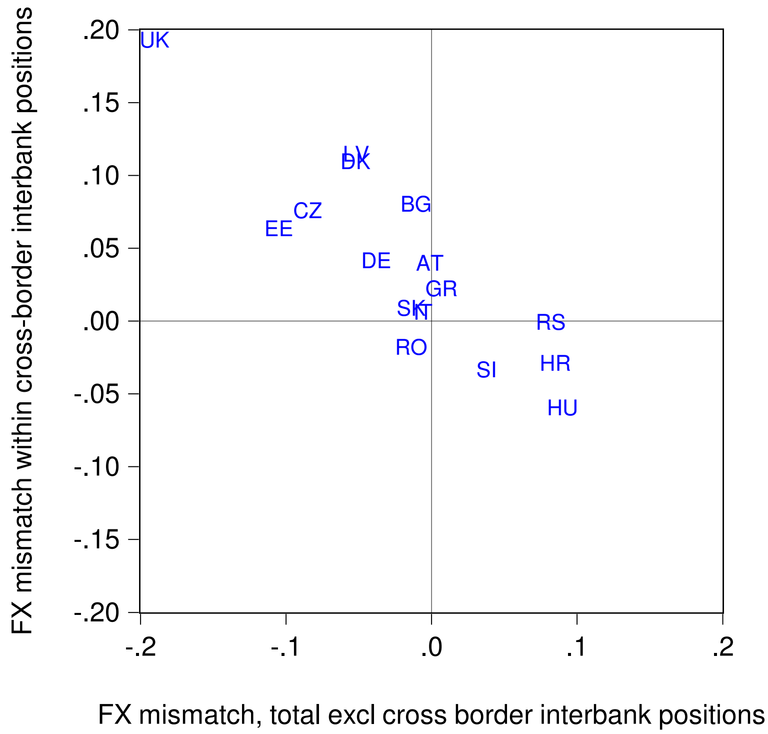


Figure 4: **Foreign currency mismatch within cross border wholesale positions vs. other positions**

Averages for 2007Q1-2016Q2. FX mismatch excluding cross border wholesale positions is computed as foreign currency assets less foreign currency lending to foreign banks less foreign currency liabilities net of liabilities to foreign banks, divided by total foreign currency assets. The foreign currency mismatch within cross border wholesale positions is also divided by total foreign currency denominated assets. Source: SFLM (Swiss National Bank).

To assess wether there is an association between net currency exposure and the unconditional correlation of bank funding flows and global factors, Figure 5 plots the country specific regression coefficients from simple country-by-country regressions of net wholesale foreign currency funding inflows in percent of total assets on lagged *gbdl* and a constant, against the country's average net foreign currency exposure. The variation in both size and sign on the vertical axis reflects substantial heterogeneity in the unconditional correlation of funding flows with global factors. Some countries tend to see inflows associated with a rise in global risk conditions, while other countries tend to see outflows. The figure suggests that countries with banking systems that are short foreign currency are more likely to see a negative association of inflows with global risk factors, while countries which are long foreign currency are less likely to exhibit such an association. Two countries in particular drive this association in

Figure 5, namely Estonia and Romania, while other countries exhibit the opposite pattern, such as Bulgaria. The regression analysis in Section 5 confirms the positive association more generally when controlling for other factors and taking into account time variation.

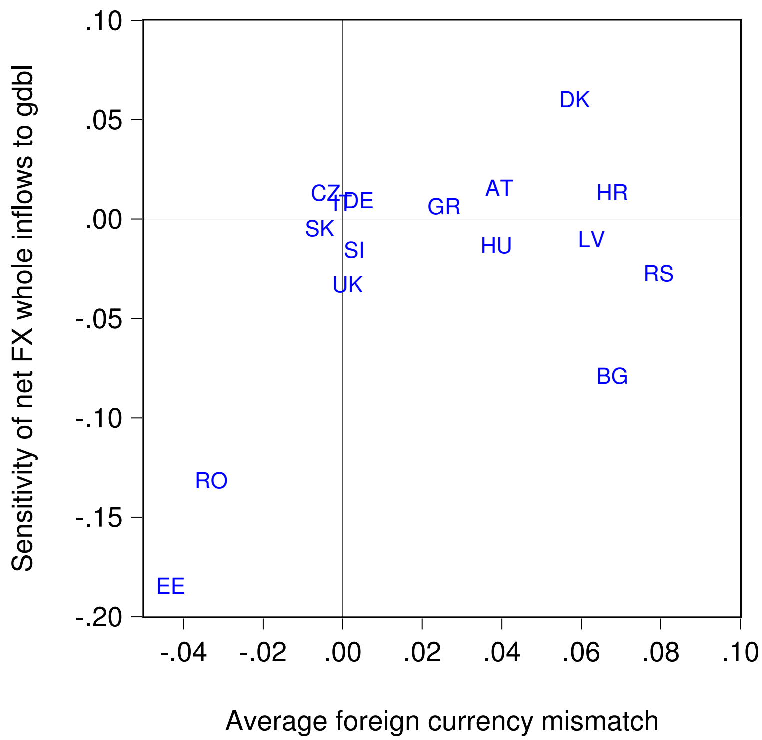


Figure 5: **Foreign currency funding sensitivity to global factor vs. net currency exposure**

The vertical axis reflects the regression coefficient from country-specific regressions of foreign currency wholesale funding inflows in percent of total assets on lagged $GBDL$ and a constant, for the sample running from 2001Q1 to 2016Q2. Using the post-crisis sample only leads to a more balanced sample across countries, and yields a similar picture. The horizontal axis reflects the sample average foreign currency mismatch as a share of total assets as depicted in Figure 3. See Appendix B for data sources.

A key question is to what extent the on-balance sheet foreign currency exposure reflects the banking sector's actual total exposure. This depends on the extent to which banks in the specific country use off-balance sheet hedging of foreign currency risk. That the regressions produce the expected significant sign for the interaction between on-balance sheet currency mismatch and the global factor, as we show below, suggests that on-balance sheet exposures do contain relevant information about total exposures, at least for some countries. The imprecision of the measure could lead to attenuation bias of the parameter estimates, suggesting that actual associations could be even stronger.

As a second approach to measuring currency exposure, we note that Expressions (3) and (4) describe the relationship between the on-balance sheet exposure and the total exposure as a function of the deviation from covered interest parity, or $Net_0^{OnB} = Net_0^{tot} + S_0 \frac{cip_{baseline}}{\alpha_{baseline}}$. Assuming that α is a constant or linearly proportional to *cip*, we then regress the net on-balance sheet exposure on the deviations from covered interest parity. The residuals from that regression are, in turn, used as an alternative proxy for the total balance sheet exposure:

$$\hat{Net}_t^{c,tot} = \varepsilon_t^c \tag{9}$$

where ε_t^c are the residuals from the panel regression $Net_t^{c,OnB} = \beta cip_t^c + \varepsilon_t^c$. As this approach relies on data on deviations from covered interest parity which are quite volatile (see below), and because other factors not included in the model that could influence the net total currency exposure of banks, such as bank regulation of risk exposures, we use this measure of total exposure only as a robustness check, and not as our main measure of currency exposure.[22]

Finally, it should be kept in mind that a dimension of banks' exposures to foreign currency, which we do not account for, is the indirect exposure through the credit risk of clients, which can be associated with foreign currency risk if clients are exposed to foreign currency risk. Banks in many European countries have issued foreign currency mortgages to clients and in turn partly hedged these on their own balance sheet, while clients will often have not hedged their resulting foreign currency exposure. Banks are likely to factor such exposures into their portfolio decisions as well.

4.2.3 Other explanatory variables

Based on the model, the empirical analysis controls for a range of other explanatory variables. We briefly discuss how these are measured here, with a more detailed description of definitions and sources (as well as information on additional data used in robustness tests) given in Appendix B. The flows of new loans and deposits in foreign currency, $d\bar{C}^{FX}$ and $d\bar{D}^{FX}$, are computed from the SFLM, adjusting for the valuation effect of exchange rates. The local risk factor is measured through the intra-quarter volatility of the exchange rate vis-à-vis the US dollar, $lvol\_USD$. The exchange rate is included in the form of the appreciation of the dollar through the quarter, d_USD. Relative funding costs in domestic and foreign currency are proxied by deviations from uncovered interest parity, $dUIP$, computed as the simple interest differential, and deviations from covered parity, $dCIP$. The computation of deviations from covered interest parity is explained in more detail in Appendix B. Currency swap markets are

[22]See also footnote 19 on using *uip* is a proxy for net exposure.

not necessarily liquid for all these countries, giving rise to rather volatile deviations, notably for Latvia (which accounts for the max and min observations of the $dCIP$ recorded in Table 1, Romania and Serbia. In robustness tests not reported here, we have used averages of the last month of the quarter instead of the last week of the quarter in order to average out some of the volatility. The regression results are largely the same, however, and deviations from covered interest parity are rarely significant in any case.

In robustness tests, we consider additional measures of global funding conditions, as described in Section 5.3, as well as country growth and inflation.

Summary statistics of all regression variables are provided in Table 1.

5 Results

5.1 Full sample

We first run the regression on the whole sample of European countries, with the results of different specifications shown in the columns of Table 2. All specifications rely on growth in US broker dealer leverage as the global factor. In Section 5.3, we consider alternative measures of the global factor including the VIX, and show that growth in US broker dealer leverage is the most relevant one for this sample of countries and the type of bank flows we are considering.

Column I shows that the global factor is not significant when it enters on its own and without other risk factors. This stands in contrast with the earlier literature, but is in line with the findings of Avdjiev et al. [2016c] that the VIX has not been a significant driver of cross-border banking flows in recent years, in contrast to earlier years. Column II shows that the global factor is significant in interaction with foreign currency exposure. A higher risk factor, as measured by an increase in *gbdl*, reduces foreign currency funding, but increases it for banks that have a long exposure, in line with the theory. This finding is consistent across the different specifications in columns II to X.

Turning to the other explanatory variables, higher exchange rate volatility, as a measure of local risk factors, reduces funding, but this impact does not depend significantly on currency exposure. Global risk factors seem to be more important in driving perceived foreign currency risk than local factors, for the banking sectors in the sample that we consider.

Realized exchange rate movements enter significantly and with the right signs through portfolio rebalancing in response to valuation effects (interaction term with net exposure), and through the risk taking channel (interaction term with the square of net exposure). We also find that wholesale funding reacts to the flows of loans granted in foreign currency, with the positive coefficient indicating a partial offsetting of new exchange rate exposure. No such

Variable	Mean	Median	Max	Min	Std. Dev.	Obs
			Euro Area Sample			
$d\bar{F}^{FX}$	-0.04	-0.06	5.01	-5.65	0.80	211
$d\bar{F}^{l}$	-0.10	-0.09	8.50	-7.86	1.55	212
Net	0.01	0.00	0.06	-0.08	0.03	216
$lvol\_USD$	-1.48	-1.44	0.20	-3.24	0.73	236
d_USD	1.47	-0.54	11.71	-9.63	4.73	254
$d\bar{C}^{FX}$	-0.07	-0.06	4.93	-5.26	0.84	212
$d\bar{D}^{FX}$	-0.08	-0.05	1.94	-2.26	0.55	208
$dUIP$	-0.01	0.02	1.16	-2.04	0.46	280
$dCIP$	-0.017	0.005	1.14	-1.38	0.34	263
			Non-Euro Countries Sample			
$d\bar{F}^{FX}$	-0.14	-0.21	7.10	-4.45	1.58	284
$d\bar{F}^{l}$	0.05	0.03	3.42	-2.50	0.76	298
Net	0.03	0.04	0.16	-0.15	0.05	303
$lvol\_USD$	-1.21	-1.21	1.37	-3.23	0.81	313
d_USD	0.81	-0.06	20.79	-16.72	5.91	345
$d\bar{C}^{FX}$	0.23	0.04	15.84	-15.45	2.37	298
$d\bar{D}^{FX}$	0.30	0.07	16.79	-4.62	2.23	298
$dUIP$	0.02	0.05	5.74	-7.02	1.26	348
$dCIP$	0.001	-0.008	4.50	-4.20	0.69	318
			Global Factors			
gbdl	1.98	1.24	25.96	-5.22	5.71	39
lvix	3.31	3.25	4.39	2.83	0.37	39

Table 1: **Data and descriptive statistics**

The euro area sample includes Austria, Estonia (post euro), Germany, Greece, Slovakia and Slovenia. The non-euro sample includes Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Latvia (before joining the euro), Romania, Serbia and the UK. $lvol\_USD$ and lD_USD are the same for all euro area countries and the number of independent observations would be 39 for these variables in the euro area sample. All variables are expressed in percentage or percentage points, except for Net, which is expressed as a ratio of total bank assets. The sample is unbalanced and runs from Q1 2007 to Q1 2016. Number of observations include all individual observations of the given variable during the sample period. The appendix presents data sources, definitions and computations in more detail.

	I	II	III	IV	V	VI	VII	VIII	IX	X
$gbdl_{-1}$	-0.008	-0.020	-0.016	-0.013	-0.033***	-0.008	0.004		0.008	-0.011
$Net_{-1} \cdot gbdl_{-1}$		1.137***	1.016***	1.172***	1.571***	1.018***	0.686**	1.347***	0.820*	1.393***
$lvol\_USD_{-1}$			-0.151*	-0.175**	-0.034	-0.208**	-0.209**	-0.121	-0.156**	-0.069
$Net_{-1} \cdot lvol\_USD_{-1}$			0.895	2.149	-0.915	3.730	3.188	1.266	1.779	0.071
d_USD_{-1}			-0.002	-0.001	-0.004	-0.002	-0.010	-0.027	0.008	-0.000
$Net_{-1} \cdot d\_USD_{-1}$			1.264**	1.275***	0.835	1.186**	1.270	1.056*	0.829**	0.695*
$Net^2_{-1} \cdot d\_USD_{-1}$			-11.62*	-12.63*	-6.754	-11.81*	-11.56	-11.01	-7.872	-4.674
Net_{-1}	-4.051	-5.454	-4.055	-2.361	-1.541	-3.466	-7.842	-3.083	-3.561	-3.605
Net^2_{-1}	7.973	4.843	3.882	3.634	-0.822	37.54	76.31	4.872	36.35	36.95
$C^{\bar{F}X}{}_{-1}$	0.215***	0.208***	0.192***	0.171**	0.091	0.121*	0.123*	0.151*	0.188**	0.113
$D^{\bar{F}X}{}_{-1}$	-0.054	-0.046	-0.029	-0.034	-0.117	-0.001	-0.006	-0.053	-0.062	-0.130*
d_UIP_{-1}	-0.077	-0.020	-0.033	-0.021	-0.011	-0.018	-0.005	0.037	-0.065	-0.050
d_CIP_{-1}	0.014	-0.030	-0.037	-0.052	-0.158	-0.051	-0.132	-0.130	-0.046	-0.171
R^2	0.15	0.17	0.15	0.20	0.21	0.23	0.19	0.28	0.19	0.20
R^2 adjusted	0.11	0.13	0.13	0.16	0.15	0.17	0.14	0.16	0.14	0.14
Nobs	459	459	459	459	400	440	412	459	455	400
No. cross sections	16	16	16	16	16	15	14	16	16	16
Sample period	Full	Full	Full	Full	PC	Full	Full	Full	Full	PC
Fixed effects	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	No	No	No	No	No	No	No	Yes	No	No

Table 2: **Main regression for the full set of countries**

The Table shows results from regressions of valuation adjusted bank wholesale funding flows in percent of total assets. The full sample runs from Q1 2007 to Q1 2016 and the post financial crisis sample (PC) starts in 2009Q2. Results in Specifications VI and VIII exclude Estonia, and Estonia and Romania, respectively. Results in specifications IX and X are based on the alternative net exposure measure given by expression (9). Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels using white cross section standard errors and covariances.

offset is seen in response to movements in deposits. We find no evidence that funding reacts short-term to deviations from interest parity, with the coefficients on changes in *uip* and *cip* deviations both insignificant.

The results are sensitive to the sample considered (with the exception of the role of the global risk factor), as many coefficients lose significance when we exclude the crisis period (column V and X, where we only consider observations from 2009Q2 on).

The salient result from Table 2 is the significance of *gbdl* interacted with exchange rate exposure. While *gbdl* also matters on its own in some specifications, its impact is primarily driven by the interaction in terms of magnitude. Consider a one standard deviation increase in *gbdl* (an increase of about 6). Using the estimates of column IV, this leads to an increase in foreign currency wholesale funding of 0.62% of assets in a country with an initial net long foreign currency exposure of 10% of assets,[23] but a contraction of foreign currency wholesale funding of 0.78% of total assets if the country initially has a net short exposure of 10%.[24]

This result is robust to changes in the specification, net exposure measure, and sample period; notably to whether fixed effect are included (columns III, IV and VIII), to using the alternative net exposure measure given by Equation (9) (columns IX and X)[25], to allowing for the parameter estimates of deviations from interest parity conditions to vary across countries (Table 6 in the appendix)[26], and to the inclusion of a number of additional control variables such as inflation, growth and US financial and monetary variables, as shown in Table 7 in the appendix. The effect of *gbdl* interacted with net currency exposure is stronger when the crisis period is omitted (column V and X in Table 2). Column VI in Table 2 shows that the result is not driven by Estonia and Romania alone, the two countries with the most clearly negative association between foreign currency exposure and the country specific unconditional sensitivity of net foreign currency funding to *gbdl* in Figure (5), although the parameter estimate becomes smaller without these countries in the sample (column VII). The specific sample of countries matters, however, and we consider this next.

5.2 Euro area vs. other European countries

Since euro area countries and non-euro countries differ strongly in their currency denomination of cross border bank funding flows, we run the regressions separately for these two sub-samples. The results are displayed in Table 3, where we again focus on the growth in

[23] $-0.013 \cdot 6 + 1.172 \cdot 0.1 \cdot 6 = 0.46\%$

[24] $-0.013 \cdot 6 - 1.172 \cdot 0.1 \cdot 6 = -0.68\%$

[25] The results are also robust to using the lagged value of the level of the deviation from *uip* as an alternative measure of net foreign currency exposure, following expression (4). Not shown but results are available on request.

[26] In robustness tests not show, we also allow the parameter estimates of the risk taking term for foreign currency appreciation to vary across countries, with no implications for the results.

broker dealer leverage as a proxy for the global factor, and include country fixed effects in all specifications.

The global factor is not significant for either group when entered alone (columns I and V). It is however significant when interacted with the net foreign currency exposure for non-euro countries (column II), but not for euro countries (column VI). The significance of the interacted global factor is robust to the inclusion of additional controls for countries outside the euro area (columns III and IV). It is also robust to the countries included in the sample. Excluding Romania (column V) as a possible outlier reduces significance somewhat but the results remain, and jointly excluding Denmark and the UK, or sequentially excluding any other country, does not change the sign and significance of the interaction term (not shown).

The pattern is quite different in the sample of euro area countries. Estonia is an outlier that strongly drives the results, and we therefore exclude it from the main euro sample in columns VI to IX, whereas columns X and XI illustrate the results including Estonia. The interaction term of the global factor with net currency exposure is never significant. The global factor is marginally significant and positive when entered on its own in the post-crisis sample period (column IX). A positive coefficient would be in line with theory, as without Estonia, euro countries are largely long foreign currency, which would predict a greater inflow as global risk conditions tighten. The data do not allow us to confirm this association, however. The lack of significance of the interaction term between the global factor and exchange rate exposure in the euro area sub-sample is quite robust.

As already noted, foreign currency funding is a marginal activity for euro-area countries, both in terms of level and first-differences. The cross-border flows of these countries are thus predominantly in domestic currency, and these are not included in the main specification. For completeness, we therefore also run the regressions using net wholesale funding flows denominated in domestic currency. The results are shown in the appendix, Table 8.[27] This change in currency denomination of cross border flows, as expected, leads to a lower fit of the regression. Moreover, the global factor remains insignificant as a driver of local currency flows in the euro area.[28]

Other drivers of foreign currency funding inflows also behave differently across euro and non-euro countries. There is some evidence of a role for the local risk factor (exchange

[27] For comparability with the previous results for the euro sub-sample, we have excluded Estonia from the euro sample, but the exclusion does not matter for the results in this specification.

[28] Interestingly, it is significant and with the right sign when interacted with exchange rate exposure in the non-euro sample. The regressions show other interesting results that are not the focus of this paper. For example, the coefficient on the deviation from uncovered interest parity is significant and negative in the full and euro sub-samples, which is not the case for foreign currency flows. Deviations from covered interest parity are significant and positive in full sample, indicating perhaps some substitution effects between foreign and domestic currency wholesale funding.

	Non-Euro Countries					Euro Area Countries					
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
$gbdl_{-1}$	-0.013	-0.032	-0.010	-0.076***	0.012	0.004	0.005	0.005	0.014*	0.001	0.014
$Net_{-1} \cdot gbdl_{-1}$		1.167***	1.039***	2.096***	0.621*		-0.310	-0.210	-0.681	-0.213	-0.580
$lvol\_USD_{-1}$			-0.425**	-0.116	-0.465**			-0.011	-0.014	-0.061	-0.034
$Net_{-1} \cdot lvol\_USD_{-1}$			5.282	1.719	5.389			0.682	0.137	2.772	1.839
d_USD_{-1}			-0.003	-0.015	-0.018			0.004	0.004	0.005	0.004
$Net_{-1} \cdot d\_USD_{-1}$			1.082**	0.942	1.166			1.833**	1.711**	0.308	0.193
$Net^2_{-1} \cdot d\_USD_{-1}$			-10.462	-6.641	-9.410			-34.72**	-34.34**	-0.136	-1.897
Net_{-1}	-7.649	-8.799***	-2.384	-9.822	-7.621	3.391	4.319	5.016	5.013	38.04***	41.77***
Net^2_{-1}	37.22	31.80	42.55	84.39	97.05	-94.22	-100.8	-94.17	-86.09	-796.6***	-796.3***
$C^{\bar{F}X}{}_{-1}$	0.183***	0.180***	0.137*	0.072	0.144**	-0.087	-0.087	-0.095	-0.146	-0.100	-0.127
$D^{\bar{F}X}{}_{-1}$	-0.022	-0.014	-0.019	-0.072	-0.029	-0.087	-0.087	-0.042	-0.012	-0.088	-0.115
d_UIP_{-1}	-0.081	-0.023	-0.032	-0.028	-0.012	-0.140**	-0.141**	-0.174***	0.004	-0.117	0.134
d_CIP_{-1}	0.013	-0.045	-0.059	-0.123	-0.129	-0.074	-0.066	-0.033	-0.155	0.056	-0.012
R^2	0.18	0.21	0.25	0.25	0.23	0.06	0.06	0.11	0.15	0.48	0.51
R^2 adjusted	0.13	0.17	0.19	0.17	0.16	0.00	0.00	0.01	0.05	0.43	0.45
Nobs	257	257	257	221	229	183	183	183	183	202	179
No. cross sections	9	9	9	9	8	6	6	6	6	7	7
Sample period	Full	Full	Full	PC	Full	Full	Full	Full	PC	Full	PC
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 3: **Main regression for euro and non-euro samples separately**

The Table shows results from regressions of valuation adjusted bank wholesale funding flows in percent of total assets. The non-euro sample includes Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Latvia (before joining the euro), Romania, Serbia and the UK. The euro area sample includes Austria, Estonia (post euro), Germany, Greece, Slovakia and Slovenia. The full sample runs from Q1 2007 to Q1 2016 and the post financial crisis sample (PC) starts in 2009Q2. Specification V excludes Romania, specifications VI-IX exclude Estonia. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels, respectively, using white cross section standard errors and covariances.

rate volatility), as well as of the use of wholesale funding as a way to offset the change in exposure due to realized exchange rate movements (positive coefficient on $Net \cdot d\_USD$) and additional foreign currency loans (positive coefficient on $d\bar{C^{FX}}$) in non-euro countries. These effects, however, lose significance once we exclude the crisis period (column IV). Funding cost differentials do not play a role. Euro area net foreign currency funding inflows respond significantly to exchange rate changes interacted with net currency exposure, and to interest rate differentials as captured by $dUIP$ in line with theory. These findings are sensitive to sample period as well as sample countries included, however.

Why are the results so different for euro and non-euro countries? While we do not have data to confirm this, one difference could be in the use of off-balance sheet hedging practises, and hence the information contents of on-balance sheet net foreign currency exposure as a proxy for total foreign currency exposure. Euro area banks use the euro dollar forward market, which is likely to be a substantially more deep and liquid market than many of the bilateral forward markets for non-euro area currencies. If this is the case, then the net foreign currency measure we use could contain more information about actual exposures in non-euro area countries.[29]

Overall, the regressions indicate that the foreign currency mismatch on bank balance sheets affects the response of cross border bank capital flows to global risk factors, especially in non-euro area countries. Omitting the interaction with exposure affects the estimates of the impact of global risk factors in some countries. The result suggests that changing balance sheet features could change the sensitivity of capital flows to global risk factors, at least in some areas of the world.

5.3 Alternative global factor measures

The literature considers a number of alternative measures of global financial factors as drivers of capital flows. Table 7 in the appendix shows that including such measures as explanatory variables in the baseline regression does not affect the results for *gbdl*. Table 4 shows the results for the regressions when including alternative global factor measures in place of *gbdl*, for the sample of all countries.

As alternative global factor measures, we consider quarterly changes in the short-term US real interest rate (3-month money market rate less inflation)[30], the quarterly change in the term spread (10-year treasury yield less the 3-month money market rate), the log of the

[29] In future extensions, this conjecture would be investigated by looking at data for the depth and liquidity of forward markets across currencies.

[30] We also tried specifying the short-term real interest rate as the shadow federal funds rate of Wu and Xia [2016] less inflation, with no difference in the results, despite the finding that this measure is much more correlated with *gbdl* in our sample.

VIX, the appreciation rate of the real effective US dollar, and two alternative measures of the US monetary policy stance. Since the Federal Funds rate has been at the zero lower bound during the larger part of the sample period, US monetary policy has been conducted with alternative tools, such as quantitative easing, forward guidance and the provision of swap lines with foreign central banks. We therefore consider the growth rate in the US monetary base and the change in the US shadow federal funds rate estimated in Wu and Xia [2016] as measures of changes in the US monetary policy stance.

	I	II	III	IV	V	VI
	dUS_RR	dUS_TS	$lvix$	dUS_REER	dUS_M0	dUS_SFFR
GF_{-1}	-0.073	0.050	-0.003	0.008	-0.004	0.011
$Net_{-1} \cdot GF_{-1}$	1.664	0.709	0.087	0.137	-0.059	-1.985
$lvol\_USD_{-1}$	-0.195**	-0.219**	-0.105	-0.221**	-0.199**	-0.208**
$Net_{-1} \cdot lvol\_USD_{-1}$	3.100	3.106	0.614	3.092	2.908	3.111
d_USD_{-1}	0.009	0.006	0.005	-0.009	0.004	0.003
$Net_{-1} \cdot d\_USD_{-1}$	1.063	1.159*	1.082*	0.939	1.109*	1.184*
$Net^2_{-1} \cdot d\_USD_{-1}$	-13.36*	-12.66**	-12.85*	-12.53	-12.76*	-12.92*
Net_{-1}	1.758	0.303	-31.531	0.253	0.134	-0.045
Net^2_{-1}	-3.474	11.060	9.168	9.110	9.533	11.235
$C^{\bar{FX}}{}_{-1}$	0.145*	0.176*	0.181**	0.181**	0.181**	0.177**
$D^{\bar{FX}}{}_{-1}$	-0.009	-0.038	-0.043	-0.048	-0.049	-0.041
d_UIP_{-1}	-0.066	-0.070	-0.080	-0.074	-0.093	-0.082
d_CIP_{-1}	-0.008	-0.025	-0.016	-0.018	0.004	-0.008
R^2	0.19	0.19	0.19	0.19	0.19	0.19
R^2 adjusted	0.13	0.13	0.14	0.14	0.13	0.13
Nobs	446	459	459	459	459	459
No. cross sections	16	16	16	16	16	16
Sample period	Full	Full	Full	Full	Full	Full
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 4: **Alternative global factors, all countries**
The Table shows results from regressions of valuation adjusted bank net wholesale funding flows in percent of total assets, for the sample of all countries. The full sample period (FULL) runs from Q1 2007 to Q1 2016 and the post-crisis sample period (PC) starts in Q2 2009. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels, respectively, using white cross section standard errors and covariances.

Table 4 shows that the alternative global factor measures considered are not significant drivers of foreign currency wholesale funding in this sample of European banking sectors.[31] Including the crisis period, or splitting the sample into euro and non-euro countries do not change these findings (not shown). The missing role of the VIX is particularly interesting, as this is the most frequently used measure of global risk factors in the literature. The result

[31] The appreciation of the broad nominal effective USD exchange rate index was also tried, without significant results in the full sample.

could reflect that the VIX is derived from US equity prices which are not strictly linked to global bank conditions. While the VIX has been found to be an important indicator of global risk and risk aversion in the literature, it may not be the most important indicator of the type of global risk factor that matters for foreign currency wholesale bank funding in our particular sample.

6 Conclusion

This paper has offered a new perspective on the link between global risk factors and the cross border foreign currency funding activity of banks. It is often argued that when global risk sentiment eases, banks are likely to increase their reliance on foreign currency funding. We have shown that one cannot expect a clear unidirectional relationship between global risk and foreign currency funding. Rather, it is important to consider how global risk affects the foreign currency risk exposure on financial institutions' balance sheets. Easing risk conditions may lead financial institutions to seek to increase their exposure to foreign currency risk. This translates into lower funding in foreign currency for institutions which are long in foreign currency (thus making the position even longer), but it translates into higher foreign currency funding for institutions with a short exposure (thus making the position even shorter).

To illustrate these effects, we have developed a simple portfolio model of the bank's foreign currency wholesale funding choice, and tested its predictions empirically for cross border bank funding flows and bank balance sheet positions in 16 European countries. When using growth in US broker dealer leverage as a measure of the global risk factor, we have shown that the effect of the global risk factor on wholesale funding flows depends qualitatively on the pre-existing foreign currency exposure of the banking sector. This finding is driven mainly by European countries that are not part of the euro area. In contrast, the relatively small foreign currency funding positions of euro area banking sectors are not sensitive to the risk factors we consider, which could reflect different off-balance sheet hedging practises.

Finally, our results have also shown that the most consistently relevant empirical global risk factor for European foreign currency wholesale funding is growth in US broker dealer leverage. Other measures used in the literature, such as the VIX, are not significant drivers in the sample of European banking sectors we have studied.

Foreign currency risk exposure in bank balance sheets varies across countries and over time, suggesting that the link between global factors and banks' foreign currency funding will also vary. We have viewed the response of banks to global risks through the prism of portfolio risk management behavior. Other factors may be at play, such as regulatory rules. Moreover, we have focused empirically on bank net funding flows, for which comprehensive balance sheet data exist that are comparable across countries. Similar comprehensive data are not readily available for other types of financial institutions intermediating an important share of cross border capital flows, such as institutional investors. Other institutions may respond differently to global factors, and we therefore cannot generalize our results to total cross border capital flows. More research and development of better data would help further our understanding of the link between domestic financial market structure and regulation on the one hand, and capital flow sensitivity to global risk and hence volatility, on the other. A better understanding could in turn help inform the design of capital flow management measures to reduce capital flow volatility.

References

Tobias Adrian and Fernando M. Duarte. Financial vulnerability and monetary policy. Staff Reports 804, Federal Reserve Bank of New York, December 2016.

Tobias Adrian and Hyun Song Shin. Procyclical Leverage and Value-at-Risk. *Review of Financial Studies*, 27(2):373–403, 2014.

Tobias Adrian, Erkko Etula, and Tyler Muir. Financial intermediaries and the cross-section of asset returns. *forthcoming, The Journal of Finance*, 2014.

Stefan Avdjiev and Elod Takats. Monetary policy spillovers and currency networks in cross-border bank lending. BIS Working Papers 549, Bank for International Settlements, March 2016.

Stefan Avdjiev, Zsolt Kuti, and Elod Takats. The euro area crisis and cross-border lending to emerging markets. *Bank for International Settlements quarterly review*, pages 37–47, 2012.

Stefan Avdjiev, Wenxin Du, Catherine Koch, and Hyun Song Shin. The dollar, bank leverage and the deviation from covered interest parity. BIS Working Papers 592, Bank for International Settlements, November 2016a.

Stefan Avdjiev, Wenxin Du, Catherine Koch, and Hyun Song Shin. The dollar, bank leverage and the deviation from covered interest parity. Working Papers 592, BIS, 2016b.

Stefan Avdjiev, Leonardo Gambacorta, Linda Goldberg, and Stefano Schiaffi. The shifting drivers of international capital flows. *BIS Mimeo*, 2016c.

Claudio Borio, Robert Neil McCauley, Patrick McGuire, and Vladyslav Sushko. Covered interest parity lost: understanding the cross-currency basis. *BIS Quarterly Review*, September 2016.

Franziska Bremus and Marcel Fratzscher. Drivers of structural change in cross-border banking since the global financial crisis. *Journal of International Money and Finance*, 52:32 – 59, 2015.

Martin Brown and Helmut Stix. The euroization of bank deposits in Eastern Europe. *paper presented at the 59th panel meeting of economic policy*, 2014.

Markus K. Brunnermeier, Stefan Nagel, and Lasse H. Pedersen. Carry Trades and Currency Crashes. In *NBER Macroeconomics Annual 2008, Volume 23*, NBER Chapters, pages 313–347. National Bureau of Economic Research, Inc, April 2009.

Valentina Bruno and Hyun Song Shin. Capital flows and the risk-taking channel of monetary policy. Working Paper 18942, National Bureau of Economic Research, April 2013.

Valentina Bruno and Hyun Song Shin. Cross-border banking and global liquidity. BIS Working Papers 458, Bank for International Settlements, Aug 2014.

Valentina Bruno and Hyun Song Shin. Global dollar credit and carry trades: a firm-level analysis. BIS Working Papers 510, Bank for International Settlements, August 2015.

Matthieu Bussiere, Julia Schmidt, and Natacha Valla. International Financial Flows in the New Normal: Key Patterns (and Why We Should Care). CEPII Policy Brief 2016-10, CEPII research center, March 2016.

Julian Caballero, Ugo Panizza, and Andrew Powell. The second wave of global liquidity: Why are firms acting like financial intermediaries? CEPR Discussion Papers 10926, C.E.P.R. Discussion Papers, November 2015.

Guillermo A. Calvo, Leonardo Leiderman, and Carmen M. Reinhart. Inflows of Capital to Developing Countries in the 1990s. *Journal of Economic Perspectives*, 10(2):123–139, Spring 1996.

Eugenio Cerutti. Drivers of cross-border banking exposures during the crisis. *Journal of Banking & Finance*, 55(C):340–357, 2015.

Eugenio Cerutti, Stijn Claessens, and Andrew K Rose. How Important is the Global Financial Cycle? Evidence from Capital Flows. CEPR Discussion Papers 12075, C.E.P.R. Discussion Papers, June 2017.

Eugenio M Cerutti, Stijn Claessens, and Damien Puy. Push Factors and Capital Flows to Emerging Markets; Why Knowing Your Lender Matters More Than Fundamentals. IMF Working Papers 15/127, International Monetary Fund, June 2015.

Eugenio M Cerutti, Stijn Claessens, and Lev Ratnovski. Global Liquidity and Cross Border Bank Flows. *Economic Policy*, 00(0):000–000, Jan 2016.

Nicola Cetorelli and Linda Goldberg. Global banks and international shock transmission: evidence from the crisis. *International Monetary Fund Economic Review*, 59:41–46, 2011.

Nicola Cetorelli and Linda Goldberg. Follow the money: Quantifying domestic effects of foreign bank shocks in the Great Recession. *American Economic Review Papers and Proceedings*, 2012.

Dong Boem Choi and Hyun-Soo Choi. The effect of monetary policy on bank wholesale funding. Staff Reports 759, Federal Reserve Bank of New York, January 2016.

Jens H. E. Christensen and Signe Krogstrup. A Portfolio Model of Quantitative Easing. Working Paper Series 2016-12, Federal Reserve Bank of San Francisco, July 2016.

Stijn Claessens and Neeltje van Horen. The impact of the global financial crisis on banking globalization. DNB Working Papers 459, Netherlands Central Bank, Research Department, February 2015.

Giovanni Dell'Ariccia, Luc Laeven, and Robert Maquez. Financial Frictions, Foreign Currency Borrowing, and Systemic Risk. Manuscript 000, IMF, Dec 2016.

Wenxin Du, Alexander Tepper, and Adrien Verdelhan. Deviations from covered interest rate parity. Working Paper 23170, National Bureau of Economic Research, February 2017.

ECB. The International Role of the Euro. Technical report, The European Central Bank, 2014.

Ingo Fender and Patrick McGuire. Bank structure, funding risk and the transmission of shocks across countries: concepts and measurement. *BIS Quarterly Review*, September 2010.

Kristin Forbes and Francis Warnock. Capital flow waves: Surges, stops, flight, and restrenchment. *Journal of International Economics*, 88:235 – 251, 2012a.

Kristin J. Forbes and Francis E. Warnock. Capital flow waves: Surges, stops, flight, and retrenchment. *Journal of International Economics*, 88(2):235–251, 2012b.

Marcel Fratzscher. Capital flows, push versus pull factors and the global financial crisis. *Journal of International Economics*, 88(2):341–356, 2012.

Atish R. Ghosh, Mahvash S. Qureshi, Jun Il Kim, and Juan Zalduendo. Surges. *Journal of International Economics*, 92(2):266–285, 2014.

Linda Goldberg and Signe Krogstrup. International Capital Flow Pressures. Paper presented at the piie-kiep-bok conference on monetary policy options for small open economies, korea, july 17, 2016, PIIE, Jul 2016.

Harald Hau and Helene Rey. Global portfolio rebalancing under the microscope. Technical report, National Bureau of Economic Research, 2008.

IMF. How Do Changes in the Investor Base and Financial Deepening Affect Emerging Market Economies? Chapter 2, Global Financial Stability Report, International Monetary Fund, Apr 2014.

David S. Scharfstein Ivashina, Victoria and Jeremy C. Stein. Dollar Funding and the Lending Behavior of Global Banks. *Quarterly Journal of Economics*, 130(3):1241–1281, Aug 2015.

Signe Krogstrup and Cédric Tille. What drives for foreign currency funding mix of banks? Manuscript 000, Graduate Institute and IMF, Nov 2017a.

Signe Krogstrup and Cédric Tille. A portfolio model of cross border bank funding. mimeo, Graduate Institute, Geneva, 2017b.

Signe Krogstrup and Cédric Tille. *On the Roles of Different Foreign Currencies in European Bank Lending*, chapter in "International Currency Exposure". CESifo Seminar Series. MIT Press, 1 edition, July 2017c.

Robert McCauley, Patrick McGuire, and Vladyslav Sushko. Global dollar credit: links to US monetary policy and leverage. Working Paper 483, Bank for International Settlements, January 2015.

Peter McQuade and Martin Schmitz. The great moderation in international capital flows: a global phenomenon? Working Paper Series 1952, European Central Bank, August 2016.

Gian-Maria Milesi-Ferretti and Cédric Tille. The great retrenchment: International capital flows during the global financial crisis. *Economic Policy*, 66:285–330, 2011.

Galo Nuno and Carlos Thomas. Bank Leverage Cycles. *American Economic Journal: Macroeconomics*, 9(2):32–72, April 2017.

Hélène Rey. Dilemma not Trilemma: The global Financial Cycle and Monetary Policy Independence. Working Paper 21162, National Bureau of Economic Research, May 2015.

Elod Takats. Was it credit supply? Cross-border bank lending to emerging market economies during the financial crisis. *Bank for International Settlements Quarterly Review*, pages 49–56, 2010.

Elod Takats and Judit Temesvary. The currency dimension of the bank lending channel in international monetary transmission. BIS Working Papers 600, Bank for International Settlements, December 2016.

Cédric Tille and Eric van Wincoop. Solving DSGE portfolio choice models with dispersed private information. *Journal of Economic Dynamics and Control*, 40(C):1–24, 2014.

Jing Cynthia Wu and Fan Dora Xia. Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound. *Journal of Money, Credit and Banking*, 48(2-3):253–291, 03 2016.

Pinar Yesin. Foreign currency loans and systemic risk in Europe. *Federal Reserve Bank of St Louis Review*, pages 219–235, 2013.

Appendix

A Theoretical model

A.1 Spot and forward exchange rates

The exchange rate in period t is:

$$S_t = S_0 \exp\left[\nu_t^S\right] \tag{10}$$

where S_0 is the zero-order baseline component of the exchange rate. ν_t^S is a first-order element that is realized in period t. ν_t^S corresponds to s_t in the main text, and captures any deviation of the exchange rate from the baseline that is already realized at the time of the funding decision. The exchange rate in period $t+1$ is:

$$S_{t+1} = S_0 \exp\left[\nu_t^S + \kappa_{t+1}^S + \tau\nu_{t+1}^S + \varepsilon_{t+1}^S\right] \tag{11}$$

where $\kappa_{t+1}^S + \tau\nu_{t+1}^S + \varepsilon_{t+1}^S$ correspond to s_{t+1} in the text. The terms κ_{t+1}^S and ν_{t+1}^S capture exchange rate movements that are expected at the time of the bank's decision. Both terms have the same economic interpretation, but each impacts a different order of the funding portfolio. Specifically, κ_{t+1}^S is a second-order term reflecting the exchange rate expectation in the baseline environment, and affects the zero-order component of the funding portfolio. ν_{t+1}^S is a first-order term, scaled by a second-order term τ, reflecting the extent to which the exchange rate expectation in the shifted environment differs from the baseline one. It affects the first-order component of the funding portfolio.[32]

ε_{t+1}^S in (11) is a standard first-order shock realized in period $t+1$. It reflects the part of the exchange rate that is unknown at the time of the funding decision. Its variance is $Var\left(\varepsilon_{t+1}^S\right)$ and its expected value is $E\left(\varepsilon_{t+1}^S\right) = -0.5Var\left(\varepsilon_{t+1}^S\right)$.[33] As risk is a major determinant of the funding portfolio, we model the variance of the exchange rate as:

$$Var\left(\varepsilon_{t+1}^S\right) = \sigma_{fx}^2\left(1 + \nu_{t+1}^\sigma\right)$$

Both σ_{fx}^2 and ν_{t+1}^σ are known in period t. σ_{fx}^2 is the second-order variance of the shock in the baseline situation. ν_{t+1}^σ is a first-order term reflecting the deviation of the variance from its baseline level. As shown below, it affects the first-order component of the funding portfolio.

We write the forward exchange rate T_{t+1} as follows:

[32] The specification of κ_{t+1}^S and ν_{t+1}^S as first-order terms and τ as a second-order term ensures a well-defined solution.

[33] The expected value differs from zero to offset the presence of a Jensen inequality term.

$$T_{t+1} = S_0 \exp\left[\nu_t^S + \kappa_{t+1}^S + \tau\nu_{t+1}^S + \kappa_{t+1}^T + \tau\nu_{t+1}^T\right]. \quad (12)$$

ν_t^S, κ_{t+1}^S and $\tau\nu_{t+1}^S$ are defined above. The terms κ_{t+1}^T and ν_{t+1}^T reflect the forward premium, each affecting a different order of the funding portfolio. κ_{t+1}^T is a second-order term reflecting the forward premium in the baseline environment, and affecting the zero-order component of the funding portfolio. ν_{t+1}^T is a first-order term, scaled by τ, that reflects the extent to which the premium in the shifted environment differs from the baseline one. It affects the first-order component of the funding portfolio. The forward premia is represented by $\kappa_{t+1}^T + \tau\nu_{t+1}^T$ which corresponds to p_{t+1} in the text.

A.2 Loans and deposits

The value of loans denominated in domestic currency is constant and written as $C^{dom} = C_0^{dom} \exp\left[\nu_t^{C,dom}\right]$. The term C_0^{dom} is the zero-order baseline value of loans, and $\nu_t^{C,dom}$ is a first-order element that is realized in period t. It captures the deviation of the loans from the baseline value, and affects the first-order component of the funding portfolio in the shifted environment. Without loss of generality, we consider that the returns on loans (as well as on deposits) is zero in the absence of shocks.

The foreign currency value of loans denominated in that currency is written similarly: $C^{for} = C_0^{for} \exp\left[\nu_t^{C,for}\right]$. The domestic currency value of these loans in the two periods is computed using (10) and (11):

$$\begin{aligned} S_t C^{for} &= S_0 C_0^{for} \exp\left[\nu_t^{C,for} + \nu_t^S\right] \\ S_{t+1} C^{for} &= S_0 C_0^{for} \exp\left[\nu_t^{C,for} + \nu_t^S + \kappa_{t+1}^S + \tau\nu_{t+1}^S + \varepsilon_{t+1}^S\right] \end{aligned}$$

Deposits are modelled along similar lines. The value of domestic currency deposits is $D^{dom} = D_0^{dom} \exp\left[\nu_t^{D,dom}\right]$. The term is the zero-order baseline value of deposits and $\nu_t^{D,dom}$ is a first-order element that is realized in period t, similar to $\nu_t^{C,dom}$. The domestic currency value of deposits denominated in foreign currency in period t and $t+1$ is:

$$\begin{aligned} S_t D^{for} &= S_0 D_0^{for} \exp\left[\nu_t^{D,for} + \nu_t^S\right] \\ S_{t+1} D^{for} &= S_0 D_0^{for} \exp\left[\nu_t^{D,for} + \nu_t^S + \kappa_{t+1}^S + \tau\nu_{t+1}^S + \varepsilon_{t+1}^S\right] \end{aligned}$$

A.3 Wholesale funding and forward contract

The value of wholesale funding in domestic currency in the first period is written as $F^{dom} = F_0^{dom} \exp\left[f_t^{dom}\right]$. Both F_0^{dom} and f_t^{dom} are chosen by the bank in period t. F_0^{dom} is a zero-order term which denotes the value in the baseline environment. The first-order term f_t^{dom} captures the difference in funding between the shifted and baseline environments. The value in the final period reflects the interest cost:

$$F_0^{dom} \exp\left[f_t^{dom} + \kappa_{t+1}^{R,dom} + \tau \nu_{t+1}^{R,dom}\right]$$

The terms $\kappa_{t+1}^{R,dom}$ and $\nu_{t+1}^{R,dom}$ are known at the time of the funding decision ($\kappa_{t+1}^{R,dom} + \tau\nu_{t+1}^{R,dom}$ corresponds to $r_{t+1}^{F,dom}$ in the text). Both reflect the interest cost of wholesale funding in domestic currency, each impacting a different order of the funding portfolio. Specifically, the second-order term $\kappa_{t+1}^{R,dom}$ reflects the interest rate in the baseline environment, and affects the zero-order component of the funding portfolio. The first-order term $\nu_{t+1}^{R,dom}$, scaled by τ, shows the extent to which the interest rate in the shifted environment differs from the baseline one. It affects the first-order component of the funding portfolio.

Funding in the foreign currency is written along similar lines. In the first period it is $F^{for} = F_0^{for} \exp\left[f_t^{for}\right]$ (in foreign currency) and $S_t F^{for} = S_0 F_0^{for} \exp\left[f_t^{for} + \nu_t^S\right]$ (in domestic currency). In the final period, the foreign currency value, including the interest cost, is:

$$F_0^{for} \exp\left[f_t^{for} + \kappa_{t+1}^{R,for} + \tau \nu_{t+1}^{R,for}\right]$$

and the domestic currency value is:

$$S_0 F_0^{for} \exp\left[f_t^{for} + \nu_t^S + \kappa_{t+1}^S + \kappa_{t+1}^{R,for} + \tau\left(\nu_{t+1}^{R,for} + \nu_{t+1}^S\right) + \varepsilon_{t+1}^S\right]$$

where the various terms have similar interpretations to the ones for domestic currency funding. In particular $\kappa_{t+1}^{R,for}$ and $\nu_{t+1}^{R,for}$ reflect the interest cost of wholesale funding in foreign currency ($\kappa_{t+1}^{R,for} + \tau\nu_{t+1}^{R,for}$ corresponds to $r_{t+1}^{F,for}$ in the text).[34]

We write the holding of the contract as $G = G_0 \exp\left[g_t\right]$, where the zero-order component G_0 denotes the value in the baseline environment and the first-order component g_t the difference between the shifted and baseline environments. Both G_0 and g_t are chosen by the bank in period t. The payoff of holding G units of the contract reflects the ex-post difference

[34] The orders of the various terms ensure a well-defined solution. Without loss of generality, we assume that the zero- and first-order terms of funding interest rates are both equal to zero (they only need to be equal for domestic and foreign currency funding).

between the forward and spot exchange rate, and the quadratic cost of holding the contract:

$$G_0 \exp [g_t] (T_{t+1} - S_{t+1}) - \frac{1}{2} T_{t+1} \left(\kappa^V_{t+1} + \tau \nu^V_{t+1}\right) (G_0 \exp [g_t])^2$$

The quadratic cost is scaled by the forward exchange rate T_{t+1} for convenience. The terms κ^V_{t+1} and ν^V_{t+1} reflect the size of the adjustment costs, and impact different orders of the bank's decision. κ^V_{t+1} is a second-order term reflecting the cost in the baseline environment, while ν^V_{t+1} is a first-order term reflecting the extent to which the cost in the shifted environment differs from the baseline one. The term $T_{t+1}\left(\kappa^V_{t+1} + \tau \nu^V_{t+1}\right)$ corresponds to α_{t+1} in the text.

A.4 Bank equity

Using our detailed notation, the equity position K_t in domestic currency in period t is:

$$\begin{aligned} K_t \quad = \quad & C_0^{dom} \exp\left(\nu_t^{C,dom}\right) - D_0^{dom} \exp\left(\nu_t^{D,dom}\right) - F_0^{dom} \exp\left(f_t^{dom}\right) \\ & + S_0 \left[C_0^{for} \exp\left(\nu_t^S + \nu_t^{C,for}\right) - D_0^{for} \exp\left(\nu_t^S + \nu_t^{D,for}\right) - F_0^{for} \exp\left(f_t^{for} + \nu_t^S\right)\right] \end{aligned}$$

Equity is the residual value of loans minus deposits and wholesale funding. In period $t+1$ equity is given by:

$$\begin{aligned} K_{t+1} \quad = \quad & C_0^{dom} \exp\left(\nu_t^{C,dom}\right) - D_0^{dom} \exp\left(\nu_t^{D,dom}\right) \\ & + S_0 C_0^{for} \exp\left[\nu_t^{C,for} + \nu_t^S + \kappa_{t+1}^S + \tau \nu_{t+1}^S + \varepsilon_{t+1}^S\right] \\ & - S_0 D_0^{for} \exp\left[\nu_t^{D,for} + \nu_t^S + \kappa_{t+1}^S + \tau \nu_{t+1}^S + \varepsilon_{t+1}^S\right] \\ & - F_0^{dom} \exp\left[f_t^{dom} + \kappa_{t+1}^{R,dom} + \tau \nu_{t+1}^{R,dom}\right] \\ & - S_0 F_0^{for} \exp\left[f_t^{for} + \nu_t^S + \kappa_{t+1}^S + \kappa_{t+1}^{R,for} + \tau\left(\nu_{t+1}^{R,for} + \nu_{t+1}^S\right) + \varepsilon_{t+1}^S\right] \\ & + S_0 G_0 \left[\begin{array}{c} \exp\left(g_t + \nu_t^S + \kappa_{t+1}^S + \kappa_{t+1}^T + \tau\left(\nu_{t+1}^S + \nu_{t+1}^T\right)\right) \\ - \exp\left(g_t + \nu_t^S + \kappa_{t+1}^S + \tau \nu_{t+1}^S + \varepsilon_{t+1}^S\right) \end{array}\right] \\ & - \frac{1}{2} S_0 \exp\left[2 g_t + \nu_t^S + \kappa_{t+1}^S + \kappa_{t+1}^T + \tau\left(\nu_{t+1}^S + \nu_{t+1}^T\right)\right]\left(\kappa_{t+1}^V + \tau \nu_{t+1}^V\right)(G_0)^2 \end{aligned}$$

A.5 First-order conditions and approximations

We allow the coefficient of relative risk aversion to shift. Specifically, we write $\gamma = \gamma_0 \exp[\gamma_t]$. The zero-order term γ_0 is the risk aversion in the baseline environment. γ_t is a first-order term which indicates how the risk aversion in the shifted environment differs from the baseline. γ_t thus represents shifts in the bank's risk aversion. Using our notation (1) is written as:

$$
\begin{aligned}
& E_t\left(K_{t+1}\right)^{-\gamma_0 \exp[\gamma_t]} \exp\left[\kappa_{t+1}^{R,dom} + \tau \nu_{t+1}^{R,dom}\right] \\
= \; & E_t\left(K_{t+1}\right)^{-\gamma_0 \exp[\gamma_t]} \exp\left[\kappa_{t+1}^{R,for} + \kappa_{t+1}^{S} + \varepsilon_{t+1}^{S} + \tau\left(\nu_{t+1}^{R,for} + \nu_{t+1}^{S}\right)\right]
\end{aligned} \tag{13}
$$

(2) is written as:

$$
\begin{aligned}
& E_t\left(K_{t+1}\right)^{-\gamma_0 \exp[\gamma_t]} \left[\exp\left(\kappa_{t+1}^{T} + \tau \nu_{t+1}^{T}\right) - \exp\left(\varepsilon_{t+1}^{S}\right)\right] \\
= \; & E_t\left(K_{t+1}\right)^{-\gamma_0 \exp[\gamma_t]} \exp\left[g_t + \kappa_{t+1}^{T} + \tau \nu_{t+1}^{T}\right] G_0\left(\kappa_{t+1}^{V} + \tau \nu_{t+1}^{V}\right)
\end{aligned} \tag{14}
$$

It is useful to define the second-order components of the deviations from uncovered and covered interest parity, and the friction in holding the forward contract as follows:

$$
\begin{aligned}
uip_{baseline} &= \kappa_{t+1}^{R} + \kappa_{t+1}^{S} - \kappa_{t+1}^{R,dom} \\
cip_{baseline} &= \kappa_{t+1}^{R} + \kappa_{t+1}^{T} + \kappa_{t+1}^{S} - \kappa_{t+1}^{R,dom} \\
\alpha_{baseline} &= \kappa_{t+1}^{V}
\end{aligned}
$$

Similarly, the third-order components of the deviations from uncovered and covered interest parity, and the friction in holding the forward contract are:

$$
\begin{aligned}
uip_{deviation} &= \tau\left(v_{t+1}^{R} + v_{t+1}^{S} - v_{t+1}^{R,dom}\right) \\
cip_{deviation} &= \tau\left(v_{t+1}^{R} + v_{t+1}^{T} + v_{t+1}^{S} - v_{t+1}^{R,dom}\right) \\
\alpha_{deviation} &= \tau \nu_{t+1}^{V}
\end{aligned}
$$

We take a cubic expansion of (13)-(14) with respect to the shocks ε's, the terms κ's and ν's and the terms f's. The expansion takes the form:

$$
0 = linear + \frac{1}{2} quadratic + \frac{1}{6} cubic
$$

In general, the linear term has first-, second- and third order components, the quadratic term has second- and third order components, and the cubic term has a third-order components. In our case, only the second- and third-order components include terms that are not zero. We use the second-order component to compute the zero-order positions F_0^{for} and G_0, and the third-order component to compute the first-order positions f_t^{for} and g_t.

The second-order components of the linear and quadratic terms of (13) are:

$$\begin{aligned} linear_F\,(2) &= (K_0)^{-\gamma_0}\,\sigma_{fx}^2\left[\frac{uip_{baseline}}{\sigma_{fx}^2}-\frac{1}{2}\right] \\ quadratic_F\,(2) &= (K_0)^{-\gamma_0}\,\sigma_{fx}^2\left[1-2\gamma_0\frac{Net_0^{tot}}{K_0}\right] \end{aligned}$$

where $uip_{baseline}=\kappa_2^R+\kappa_2^S-\kappa_2^{R,dom}$. Combining these leads to Net_0^{tot} in (**??**).

The second-order components of the linear and quadratic terms of (14) are:

$$\begin{aligned} linear_G\,(2) &= (K_0)^{-\gamma_0}\left[\kappa_{t+1}^T+\frac{1}{2}\sigma_{fx}^2-G_0\kappa_{t+1}^V\right] \\ quadratic_G\,(2) &= -quadratic_F\,(2) \end{aligned}$$

Combining these terms and the solution for Net_0^{tot} we get G_0 in (4).

The third-order components of the linear, quadratic and cubic terms of (13) are):

$$\begin{aligned} linear_F\,(3) &= (K_0)^{-\gamma_0}\left[uip_{deviation}-\frac{1}{2}\sigma_{fx}^2\nu_{t+1}^\sigma\right] \\ quadratic_F\,(3) &= (K_0)^{-\gamma_0}\,\sigma_{fx}^2\left[\nu_{t+1}^\sigma-2\gamma_0\frac{Net_0^{tot}}{K_0}\nu_{t+1}^\sigma\right] \\ &\quad -2\gamma_0\,(K_0)^{-\gamma_0}\,\sigma_{fx}^2\left[\frac{uip_{baseline}}{\sigma_{fx}^2}-\frac{1}{2}\right]\left[\ln(K_0)\,\gamma_t+\frac{Net_0^{OnB}}{K_0}\nu_t^S\right] \end{aligned}$$

and:

$$\begin{aligned} cubic_F\,(3) &= (K_0)^{-\gamma_0}\,\sigma_{fx}^2\left[-6\gamma_0\,[1-\gamma_0\ln(K_0)]\,\frac{Net_0^{tot}}{K_0}-3\gamma_0\ln(K_0)\right]\gamma_t \\ &\quad -(K_0)^{-\gamma_0}\,\sigma_{fx}^2 6\gamma_0\,(-\gamma_0-1)\,\frac{Net_0^{OnB}}{K_0}\frac{Net_0^{tot}}{K_0}\nu_t^S \\ &\quad -6\gamma_0\,(K_0)^{-\gamma_0-1}\,\sigma_{fx}^2\left[\begin{array}{c} Net_0^{tot}\nu_t^S+S_0C_0^{for}\nu_t^{C,for} \\ -S_0D_0^{for}\nu_t^{D,for}-S_0F_0^{for}f_t^{for}-S_0G_0^{for}g_t \end{array}\right] \\ &\quad -3\gamma_0\,(K_0)^{-\gamma_0-1}\,Net_0^{OnB}\sigma_{fx}^2\nu_t^S \end{aligned}$$

Combining these terms we write:

$$S_0 F_0^{for} f_t^{for} = -S_0 G_0 g_t - \frac{K_0}{\gamma_0} \frac{uip_{deviation}}{\sigma_{fx}^2} + Net_0^{tot} \nu_t^S + S_0 C_0^{for} \nu_t^{C,for} - S_0 D_0^{for} \nu_t^{D,for} + Net_0^{tot} \left(\gamma_t + \nu_{t+1}^{\sigma}\right) - Net_0^{OnB} \frac{Net_0^{tot}}{K_0} \nu_t^S \tag{15}$$

The third-order components of the linear, quadratic and cubic terms of (14) are:

$$\begin{aligned} linear_G(3) &= (K_0)^{-\gamma_0} \left[\tau \nu_{t+1}^T + \frac{1}{2} \sigma_{fx}^2 \nu_{t+1}^{\sigma} - G_0 \tau \nu_{t+1}^V\right] \\ quadratic_G(3) &= 2(K_0)^{-\gamma_0} \left[-\frac{1}{2} \sigma_{fx}^2 \nu_{t+1}^{\sigma} - G_0 \kappa_{t+1}^V g_t + \gamma_0 \frac{Net_0^{tot}}{K_0} \sigma_{fx}^2 \nu_{t+1}^{\sigma}\right] \\ &\quad -2(K_0)^{-\gamma_0} \gamma_0 \left[\kappa_{t+1}^T - G_0 \kappa_{t+1}^V + \frac{1}{2} \sigma_{fx}^2\right] \left(\ln(K_0) \gamma_t + \frac{Net_0^{OnB}}{K_0} \nu_t^S\right) \\ cubic_G(3) &= -cubic_F(3) \end{aligned}$$

Combining these terms and (15) we obtain:

$$g_t = \frac{cip_{deviation}}{cip_{baseline}} - \frac{\alpha_{deviation}}{\alpha_{baseline}} \tag{16}$$

While the notation in terms of percentage changes from the baseline allocation (f_t^{for}, g_t, $\nu_t^{C,for}$, $\nu_t^{D,for}$) is convenient to derive the solution, it has to be handled carefully when drawing testable implications. This is because the zero order positions (F_0^{for}, G_0, C_0^{for}, D_0^{for}) can be zero, or even negative. It is thus convenient to write (**??**) and (16) with the first-order components in units of domestic currency instead of percentage terms. Specifically:[35]

$$\begin{aligned} G_t &= G_0 g_t \\ C_t^{dom} &= C_0^{dom} \nu_t^{C,dom} \quad ; \quad C_t^{for} = C_0^{for} \nu_t^{C,for} \\ D_t^{dom} &= D_0^{dom} \nu_t^{D,dom} \quad ; \quad D_t^{for} = D_0^{for} \nu_t^{D,for} \end{aligned}$$

With this notation (15) is rewritten as (6) and (16) is written as (5).

[35]These equalities hold only up to a linear approximation, which is sufficient for our purpose.

B Data

The Swiss Franc Lending Monitor contains end-of-quarter bank balance sheet positions. We match these with relevant end-of-quarter positions of the following financial variables:

- $d\bar{F}^{FX}$ is the exchange rate valuation adjusted change in net foreign currency wholesale funding in percent of total bank assets, quarterly, end of quarter. Source: Swiss Franc Lending Monitor. Net wholesale funding for the banking sector as a whole is proxied by lending to and deposits from foreign banks. For Austria, Czech Republic and Denmark, data on total assets is not reported. We have instead used total lending for these countries.

- $d\bar{F}^{l}$ is the change in net domestic currency wholesale funding in percent of total bank assets, quarterly, end of quarter. Net wholesale funding for the banking sector as a whole is proxied by lending to and deposits from foreign banks. Source: Swiss Franc Lending Monitor. For Austria, Czech Republic and Denmark, data on total assets is not reported. We have instead used total lending for these countries.

- Net is total foreign currency assets less total foreign currency liabilities as a share of total assets. Source: Swiss Franc Lending Monitor. For Austria, Czech Republic and Denmark, data on total assets and liabilities is not reported. We have instead used total lending and total deposits plus own securities instead of assets and liabilities respectively for these countries.

- $d\bar{C}^{FX}$ is the exchange rate valuation adjusted change in foreign currency assets net of wholesale assets (as defined above) in percent of total bank assets, quarterly, end of quarter. Source: Swiss Franc Lending Monitor. For Austria, Czech Republic and Denmark, data on total assets is not reported. We have instead used total lending for these countries.

- $d\bar{D}^{FX}$ is the exchange rate valuation adjusted change in foreign currency liabilities net of wholesale liabilities (as defined above) in percent of total bank assets, quarterly, end of quarter. Source: Swiss Franc Lending Monitor. For Austria, Czech Republic and Denmark, data on total assets is not reported. We have instead used total lending for these countries.

- $lvix$. The log of the VIX, the options based expected stock price volatility, based on the S&P 500, calculated by the CBOE. Highest daily realized value of quarter (end of quarter has been used alternatively). Source: Datastream.

- *gbdl*. Quarterly percentage growth in US Broker Dealer Leverage as defined in Adrian et al. [2014], page 9, multiplied by minus one. Source: US Financial Accounts (http://www.federalreserve.gc Quarterly, based on end-of-quarter accounts.

- $lvol\_USD$. The log of the quarterly average of squared daily percentage changes of the nominal exchange rate of the local currency against the USD (quarterly mean of $(100 * dlog(S_t))^2$, where S_t is the USD exchange rate obtained from Datastream.

- d_USD. Percentage nominal appreciation of the US dollar over the quarter, where the exchange rate is measured as the average of daily exchange rates of the local currency per foreign currency unit in the last week of the quarter. Daily date is obtained from Datastream. Exchange rate data (for other foreign currencies) are also used for valuation adjusting flows as well as directly in the regressions. Bank balance sheet positions are recorded end of quarter, and to match the exchange rate but avoiding most of the volatility of daily data, we use the average daily rate in the last week of the quarter. Due to an abnormal move in the exchange rate for Romania between last quarter of 2014 and first quarter of 2015, we exclude these observations for Romania.

- $dUIP$. Quarterly changes in deviations from uncovered interest parity are computed as changes in the simple USD-domestic interest differential based on 3-month money market interest rates, with the underlying assumption that expected appreciation is zero. 3-month Libor interest rates in all currencies are in % p.a and are obtained daily from Bloomberg. We use the average of the daily observations over the last week of the quarter in the regressions.

- $dCIP$. Quarterly changes in deviations from covered interest parity are computed daily based on data for 3-month forward premiums and spot rates against the USD, as well as 3-month Libor rates, obtained from Bloomberg. Interest rates are in % p.a. and the average for the last week of the quarter is used in the regressions. Du et al. [2017] show that there is a spike in the deviations from covered interest parity in the last days of the quarter for a sample of European countries, which they link to regulation related balance sheet constraints. These spikes are mainly found for shorter maturity deviations (overnight and one-week deviations), however. We have verified that such spikes are not observable in our data, which allows us to use the average the last week of the quarter as representative (using the second to last week of quarter does not change results).

- dUS_TS. Quarterly change in the US term premium. 10-year government bond yield less 3-month money market interest rate (in % p.a.). Source: Haver Analytics.

- dUS_RR. The US short-term real interest rate. 3-month USD money market interest rate, average for the last week of the quarter, less US realized annualized inflation rate as defined below, in % p.a. Source: Bloomberg and Haver Analytics.
- d_US_REER. The quarterly percentage change (annualized) in the real effective exchange rate of the USD. Last month of quarter. Source: IFS.
- dUS_M0. The quarterly percentage change in the US monetary base. Source: IFS.
- dUS_SFFR. Quarterly change in the shadow Federal Fund Rate computed in Wu and Xia [2016], in % p.a. Monthly averages, last month of the quarter is used in regressions.
- Inflation: Percentage change in the consumer price index between last month of quarter and same quarter the previous year. Source: Haver Analytics.
- Growth: Percentage change between quarterly real GDP and the same quarter the previous year. Source: Haver Analytics.

C Adjusting bank positions for exchange rate valuation effects

Changes in net funding positions across currencies are adjusted for changes due to exchange rate movements, based on the data available from the Swiss Franc Lending Monitor and other sources. Consider the wholesale funding position of country c in a foreign currency j. We denote its value in domestic currency at the end of period t by $L_t^{c,j}$. The total change in the value of the position between periods $t-1$ and t consists of the active change in that position, $F_t^{c,j}$, and the valuation impact of the exchange rate. We denote the exchange rate in terms of units of local currency per unit of foreign currency as $S_t^{c,j}$ (so an increase is an appreciation of the foreign currency). The dynamics of the position are then:

$$L_t^{c,j} = L_{t-1}^{c,j} + F_t^{c,j} + L_{t-1}^{c,j} dln(S_t^{c,j})$$

Which we rewrite as:

$$\dot{l}_t^{c,j} = f_t^{c,j} + \dot{S}_t^{c,j}$$

where $\dot{l}_t^{c,j} = dL_t^{c,j}/L_{t-1}^{c,j}$, $f_t^{c,j} = F_t^{c,j}/L_{t-1}^{c,j}$ and $\dot{S}_t^{c,j} = dln(S_t^{c,j})$. There is one such relation for positions in CHF and one for positions in other foreign currencies. The latter is a weighted sum across various currencies, where $\varpi^{c,j}$ is the share of foreign currency j in the other foreign currency positions (i.e. foreign currency positions excluding Swiss franc positions):

$$\dot{l}_t^{c,CH} = f_t^{c,CH} + \dot{S}_t^{c,CH} \quad (17)$$

$$\dot{l}_t^{c,FX} = f_t^{c,FX} + \sum_j \varpi^{c,j} \dot{S}_t^{c,j} \quad (18)$$

where $f_t^{c,FX} = \sum_j \varpi^{c,j} f_t^{c,j}$ and $\dot{l}_t^{c,FX} = \sum_j \varpi^{c,j} \dot{l}_t^{c,j}$.

The Swiss franc lending monitor provides us with the changes in positions, $\dot{l}_t^{c,CH}$ and $\dot{l}_t^{c,FX}$, but not the individual $\dot{l}_t^{c,j}$. We also observe exchange rates $\dot{S}_t^{c,CH}$ and the various $\dot{S}_t^{c,j}$. While we can directly back out the active portfolio changes in CHF positions $f_t^{c,CH}$, we need to estimate these for positions in other foreign currencies, $f_t^{c,FX}$. To do this, we construct empirical estimates of the weights $\varpi^{c,j}$. We have relied on three sources. The first is the ECB annual report on the international role of the euro (ECB [2014]). This publication gives the composition of overall deposits and bank loans for selected countries. This source suggests that in many cases, one currency (primarily the euro) plays a overwhelming role, and in these cases, we assume that the non-CHF positions in foreign currencies are in that currency.

The second source is the results from regression analyses, where we assume that exchange rate movements immediately affect the local currency value of the positions denominated in foreign currencies, but affect outright flows only with a lag. Regressing $\dot{l}_t^{c,FX}$ on the various $\dot{S}_t^{c,j}$ then gives estimates for the coefficients $\varpi^{c,j}$ in (18). We run such a regression for each country, considering the euro, US dollars, British pounds and yen as foreign currencies. The coefficients are re-scaled to add up to one, giving us estimates for $\varpi^{c,j}$. When the regression results provide a good fit for the composition across several currencies, we rely on them. In some cases the regression results are problematic, for instance when the country has a peg against the euro. In these cases, we rely on a third source, namely information on web sites of the European Central Bank and a number of the national central banks of the sample countries. Table 5 lists the approach taken to select weights, as well as the chosen weights, for each of the sample countries. The weights apply to non-Swiss franc foreign currency positions and sum to one. When only one set of weights is provided, it means that we apply the same set of weights to both assets and liabilities positions. For some countries, data availability or regression results allows us to apply weights specific to assets and liabilities respectively, and in these cases, the table clearly distinguishes these.

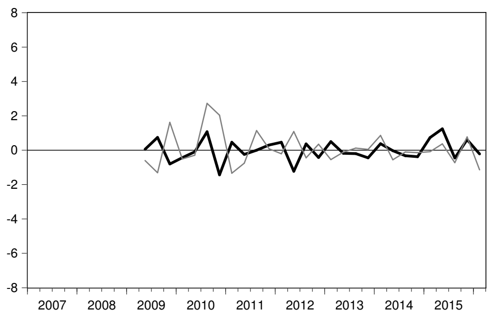
Finally, we acknowledge that currency weights may have changed across the sample. Data does not allow us such detail. The potential for changing currency compositions across the sample suggests a source of inaccuracy that we cannot account for.

Country	Approach	Sources	Weighting Scheme
AT	The Austrian central bank reports that the bulk of non-CHF FX lending to domestic households is in Yen. Non-CHF FX lending to domestic non-financial firms is about one quarter in yen, the rest is in other currencies. The bulk of foreign currency lending in Austria is to households. The central bank offers no information on currency breakdown of foreign currency deposits or other liabilities. Since the SFLM does not report total assets and total liabilities for Austria, we have used total lending and total deposits for Austria instead. We consider that all non-CHF FX is in yen for all subcategories.	Austria National Bank[a]	$\varpi^{USD}=0$, $\varpi^{EUR}=0$, $\varpi^{JPY}=1$, $\varpi^{GBP}=0$
BG	Bulgaria's non-CHF FX positions are largely in euros (see Brown and Stix [2014]). Bulgaria has pegged to the euro during the sample period, and we have hence excluded the euro from the regressions. Given the overwhelming role of the euro, we consider that all non-CHF FX is in euro for all subcategories.		$\varpi^{USD}=0$, $\varpi^{EUR}=1$, $\varpi^{JPY}=0$, $\varpi^{GBP}=0$
CZ	Czech banks non-CHF FX positions are primarily denominated in euro, but also has USD denominated positions	ECB [2014]	$\varpi^{USD}_{assets}=0.1$, $\varpi^{EUR}_{assets}=0.9$, $\varpi^{JPY}_{assets}=0.00$, $\varpi^{GBP}_{assets}=0.00$, $\varpi^{USD}_{liab}=0.07$, $\varpi^{EUR}_{liab}=0.93$, $\varpi^{JPY}_{liab}=0.00$, $\varpi^{GBP}_{liab}=0.00$
DE	Bundesbank offers detailed data on currency composition of non-euro assets and liabilities vis-Ã -vis residents (but not for non-residents), which we use for selecting weights.	Bundesbank[b]	$\varpi^{USD}_{assets}=0.78$, $\varpi^{EUR}_{assets}=0$, $\varpi^{JPY}_{assets}=0.06$, $\varpi^{GBP}_{assets}=0.16$, $\varpi^{USD}_{liab}=0.84$, $\varpi^{EUR}_{liab}=0$, $\varpi^{JPY}_{liab}=0.03$, $\varpi^{GBP}_{liab}=0.14$
DK	Danmarks Nationalbank provides detailed information on currency composition of bank balance sheets in line with information provided by the ECB.	Danmarks Nationalbank and ECB [2014]	$\varpi^{USD}_{assets}=0.20$, $\varpi^{EUR}_{assets}=0.75$, $\varpi^{JPY}_{assets}=0.01$, $\varpi^{GBP}_{assets}=0.04$, $\varpi^{USD}_{liab}=0.30$, $\varpi^{EUR}_{liab}=0.64$, $\varpi^{JPY}_{liab}=0.02$, $\varpi^{GBP}_{liab}=0.05$
EE	For Estonia after joining the euro, we apply the regression results.		$\varpi^{USD}_{assets}=0.75$, $\varpi^{EUR}_{assets}=0.00$, $\varpi^{JPY}_{assets}=0.10$, $\varpi^{GBP}_{assets}=0.15$, $\varpi^{USD}_{liab}=0.75$, $\varpi^{EUR}_{liab}=0.00$, $\varpi^{JPY}_{liab}=0.10$, $\varpi^{GBP}_{liab}=0.15$
UK	The regression estimates of currency weights are plausible, and we have based the currency weights that we use on these.		$\varpi^{USD}_{assets}=0.28$, $\varpi^{EUR}_{assets}=0.58$, $\varpi^{JPY}_{assets}=0.14$, $\varpi^{GBP}_{assets}=0.00$, $\varpi^{USD}_{liab}=0.26$, $\varpi^{EUR}_{liab}=0.58$, $\varpi^{JPY}_{liab}=0.16$, $\varpi^{GBP}_{liab}=0.00$
GR	The Greek central bank homepage offers detailed information on currency breakdown for lending and deposits in non-CHF foreign currency across time. We have computed currency weight averages for the sample period based on these data.	Bank of Greece[c]	$\varpi^{USD}_{assets}=0.97$, $\varpi^{EUR}_{assets}=0.00$, $\varpi^{JPY}_{assets}=0.03$, $\varpi^{GBP}_{assets}=0.00$, $\varpi^{USD}_{liab}=0.83$, $\varpi^{EUR}_{liab}=0.00$, $\varpi^{JPY}_{liab}=0.12$, $\varpi^{GBP}_{liab}=0.04$
HR	For Croatia, we do not have access to information on currency breakdown and the regression results are not reasonable. We instead consider that all non-CHF foreign currency is in euro for all subcategories.		$\varpi^{USD}=$, $\varpi^{EUR}=$, $\varpi^{JPY}=$, $\varpi^{GBP}=$
HU	The regression estimates of currency weights for Hungary are plausible and in line with the information in ECB [2014], and we have based the currency weights on these.		$\varpi^{USD}_{assets}=0.34$, $\varpi^{EUR}_{assets}=0.66$, $\varpi^{JPY}_{assets}=0.00$, $\varpi^{GBP}_{assets}=0.00$, $\varpi^{USD}_{liab}=0.08$, $\varpi^{EUR}_{liab}=0.92$, $\varpi^{JPY}_{liab}=0.00$, $\varpi^{GBP}_{liab}=0.00$
IT	We rely on the regression results for Italy.		$\varpi^{USD}_{assets}=0.80$, $\varpi^{EUR}_{assets}=0.00$, $\varpi^{JPY}_{assets}=0.10$, $\varpi^{GBP}_{assets}=0.10$, $\varpi^{USD}_{liab}=0.80$, $\varpi^{EUR}_{liab}=0.00$, $\varpi^{JPY}_{liab}=0.10$, $\varpi^{GBP}_{liab}=0.10$
LV	Latvia has pegged to the euro during the sample period, and we have hence excluded the euro from the regressions. We otherwise rely on ECB [2014] for determining FX currency weights for Latvia.	ECB [2014]	$\varpi^{USD}_{assets}=0.03$, $\varpi^{EUR}_{assets}=0.97$, $\varpi^{JPY}_{assets}=0.00$, $\varpi^{GBP}_{assets}=0.00$, $\varpi^{USD}_{liab}=0.13$, $\varpi^{EUR}_{liab}=0.87$, $\varpi^{JPY}_{liab}=0.00$, $\varpi^{GBP}_{liab}=0.00$
RO	Romania's central bank provides data on currency breakdown of lending and deposits.	National Bank of Romania[d]	$\varpi^{USD}_{assets}=0.04$, $\varpi^{EUR}_{assets}=0.96$, $\varpi^{JPY}_{assets}=0.00$, $\varpi^{GBP}_{assets}=0.00$, $\varpi^{USD}_{liab}=0.08$, $\varpi^{EUR}_{liab}=0.92$, $\varpi^{JPY}_{liab}=0.00$, $\varpi^{GBP}_{liab}=0.00$
RS	Serbia's central bank provides detailed statistics on currency breakdown of lending to and deposits from residents, largely confirming ECB numbers which we use for Serbia.	National Bank of Serbia[e] and ECB [2014].	$\varpi^{USD}_{assets}=0.12$, $\varpi^{EUR}_{assets}=0.88$, $\varpi^{JPY}_{assets}=0.00$, $\varpi^{GBP}_{assets}=0.00$, $\varpi^{USD}_{liab}=0.06$, $\varpi^{EUR}_{liab}=0.94$, $\varpi^{JPY}_{liab}=0.00$, $\varpi^{GBP}_{liab}=0.00$
SI	For Slovenia after joining the euro, non-CHF FX are overwhelmingly denominated in USD for assets as well as liabilities.		$\varpi^{USD}=1$, $\varpi^{EUR}=0$, $\varpi^{JPY}=0$, $\varpi^{GBP}=0$
SK	For Slovakia after joining the euro, we apply the regression results.		$\varpi^{USD}_{assets}=0.88$, $\varpi^{EUR}_{assets}=0.00$, $\varpi^{JPY}_{assets}=0.12$, $\varpi^{GBP}_{assets}=0.00$, $\varpi^{USD}_{liab}=0.76$, $\varpi^{EUR}_{liab}=0.00$, $\varpi^{JPY}_{liab}=0.00$, $\varpi^{GBP}_{liab}=0.24$

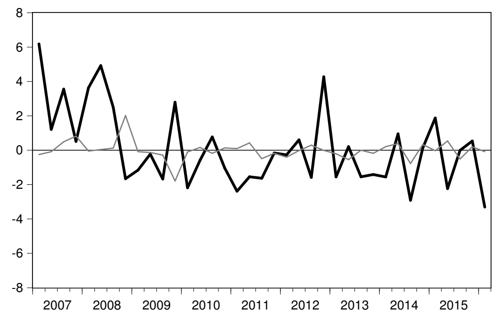
[a] http://www.oenb.at/isaweb/report.do?report=3.78.
[b] Table 19, http://www.bundesbank.de/Navigation/DE/Statistiken/Banken_und_andere_finanzielle_Institute/Banken/Tabellen/tabellen.html, or http://www.bundesbank.de/Redaktion/DE/Downloads/Statistiken/Banken_Und_Andere_Finanzielle_Institute/Banken/Banken_In_Deutschland/S134ATB188.pdf
[c] http://www.bankofgreece.gr/Pages/en/Statistics/monetary/assets_debit.aspx
[d] http://www.bnro.ro/Loans-to-households-6374.aspx
[e] http://www.nbs.rs/internet/english/80/index.html

Table 5: **Estimates of currency weights in non-Swiss franc FX bank positions**

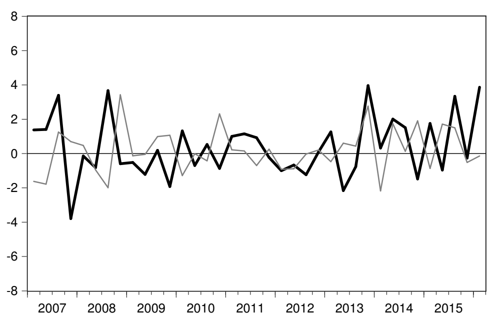
D Appendix Figures



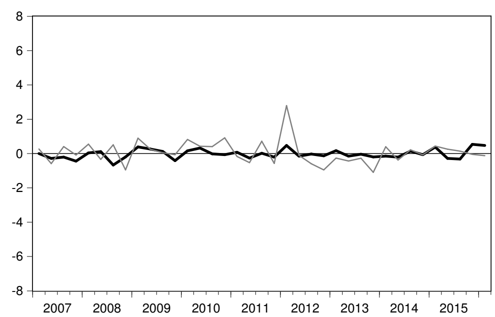
(a) Austria



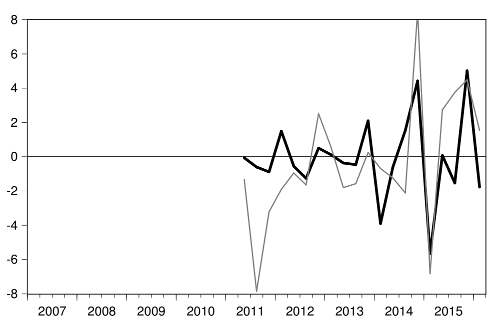
(b) Bulgaria



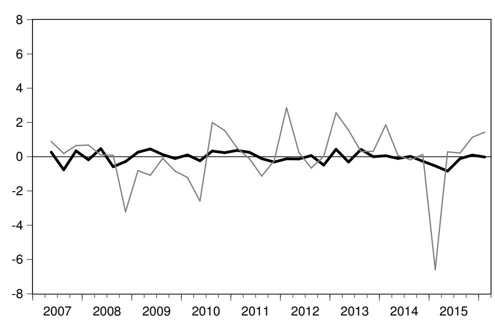
(c) Czech Republic



(d) Germany

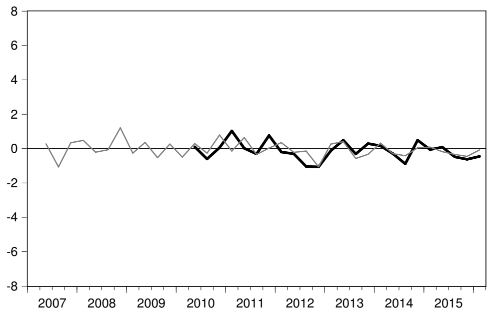


(e) Estonia

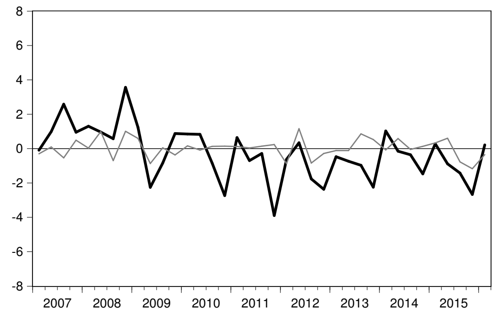


(f) Greece

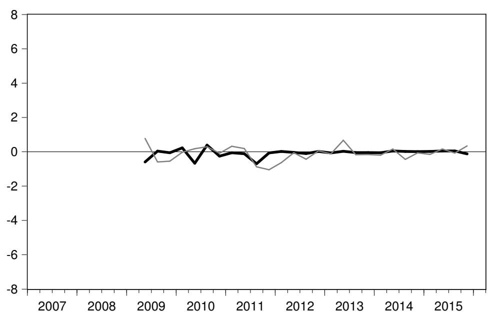
Figure 6: **Net foreign currency and domestic currency wholesale funding inflows**
The black line is quarterly valuation adjusted change in foreign currency interbank funding less foreign currency interbank lending, divided by total bank assets. The gray line is quarterly domestic currency foreign interbank funding less domestic currency foreign interbank lending, divided by total bank assets. Valuation adjusted as in Krogstrup and Tille [2017a]. Source: The Swiss Franc Lending Monitor, SNB



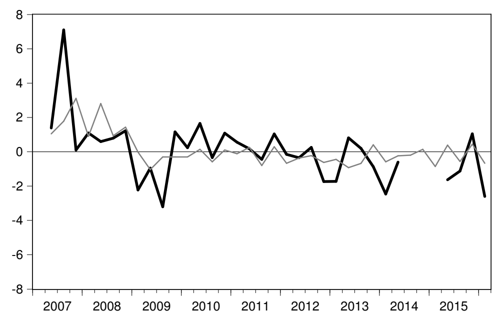
(a) Croatia



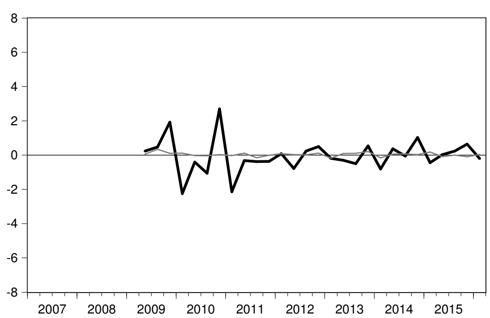
(b) Hungary



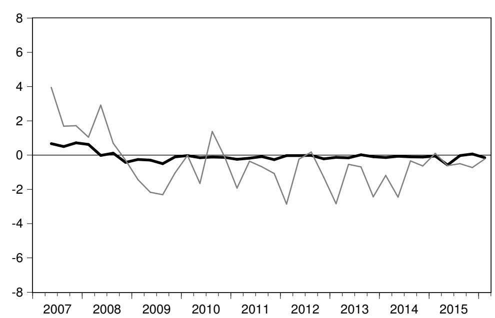
(c) Italy



(d) Romania

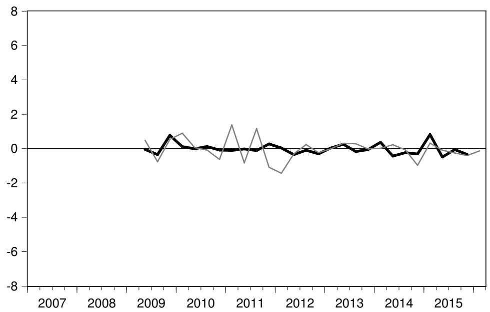


(e) Serbia

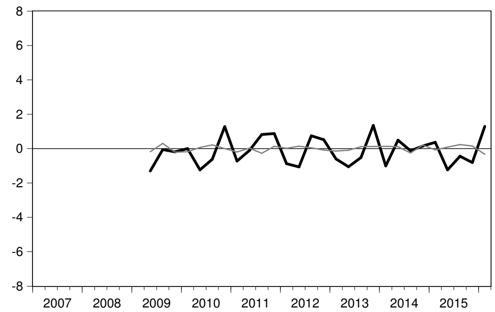


(f) Slovenia

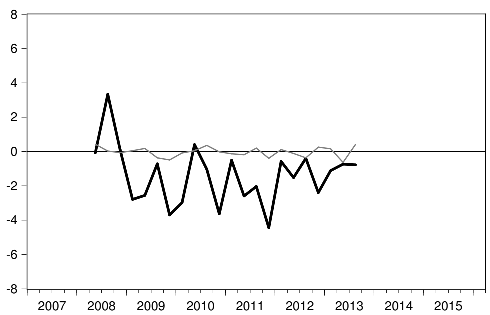
Figure 7: **Net total and foreign currency wholesale funding inflows**
The black line is quarterly valuation adjusted change in foreign currency interbank funding less foreign currency interbank lending, divided by total bank assets. The gray line is quarterly domestic currency foreign interbank funding less domestic currency foreign interbank lending, divided by total bank assets. Valuation adjusted as in Krogstrup and Tille [2017a]. Source: The Swiss Franc Lending Monitor, SNB



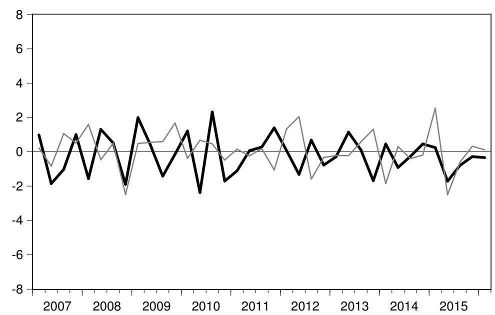
(a) Slovakia



(b) United Kingdom



(c) Latvia



(d) Denmark

Figure 8: **Net total and foreign currency wholesale funding inflows**
The black line is quarterly valuation adjusted change in foreign currency interbank funding less foreign currency interbank lending, divided by total bank assets. The gray line is quarterly domestic currency foreign interbank funding less domestic currency foreign interbank lending, divided by total bank assets. Valuation adjusted as in Krogstrup and Tille [2017a]. Source: The Swiss Franc Lending Monitor, SNB

(a) Austria

(b) Bulgaria

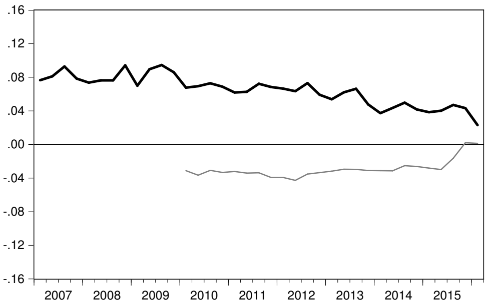
(c) Czech Republic

(d) Germany

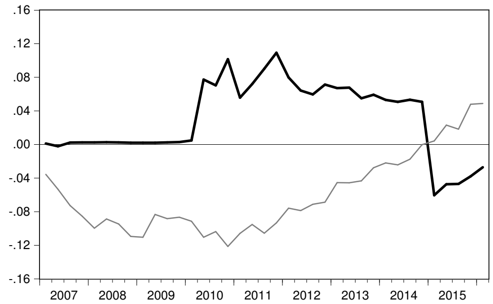
(e) Estonia

(f) Greece

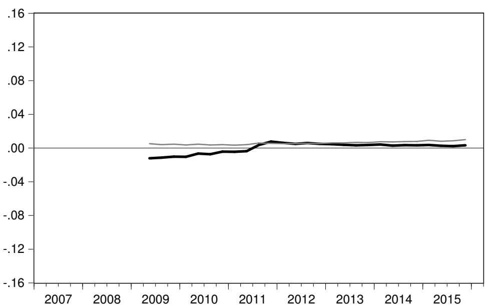
Figure 9: **Foreign currency mismatch.**
The black line is the difference between foreign currency assets and foreign currency liabilities as a share of total bank assets. The gray line is foreign currency interbank cross border lending less similarly defined funding, as a share of total bank assets. Source: The Swiss Franc Lending Monitor, SNB.



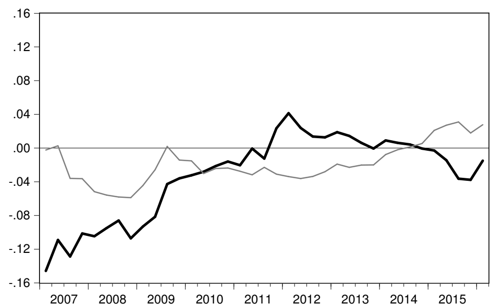
(a) Croatia



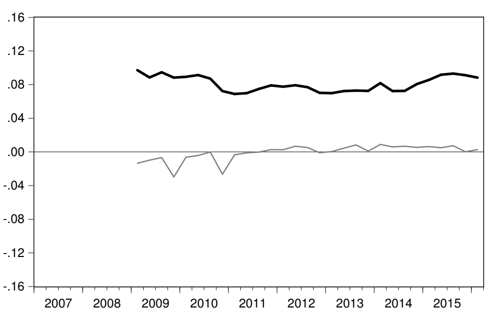
(b) Hungary



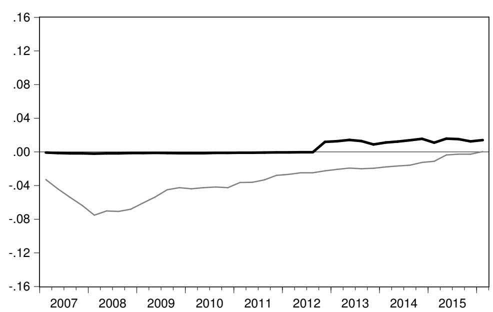
(c) Italy



(d) Romania

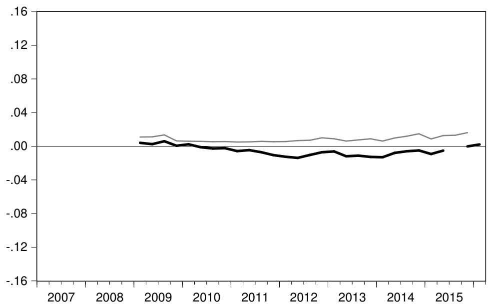


(e) Serbia

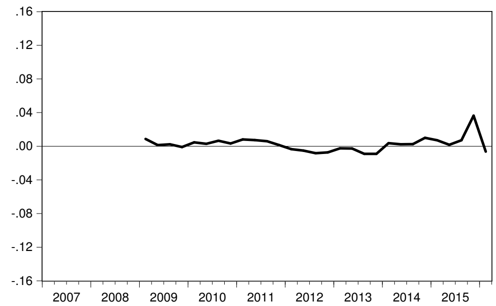


(f) Slovenia

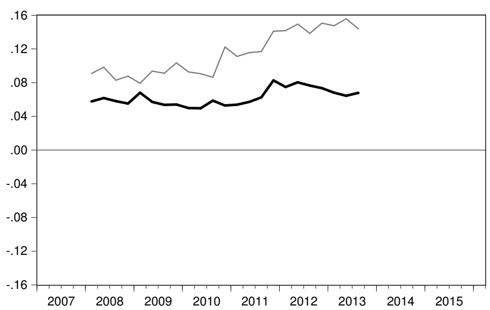
Figure 10: **Foreign currency mismatch.**
The black line is the difference between foreign currency assets and foreign currency liabilities as a share of total bank assets. The gray line is foreign currency interbank cross border lending less similarly defined funding, as a share of total bank assets. Source: The Swiss Franc Lending Monitor, SNB.



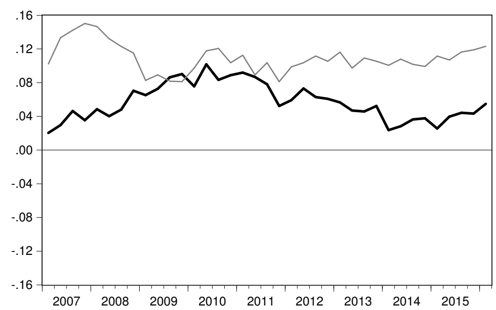
(a) Slovakia



(b) United Kingdom



(c) Latvia



(d) Denmark

Figure 11: **Foreign currency mismatch.**
The black line is the difference between foreign currency assets and foreign currency liabilities as a share of total bank assets. The gray line is foreign currency interbank cross border lending less similarly defined funding, as a share of total bank assets. Source: The Swiss Franc Lending Monitor, SNB.

E Appendix tables

	All I	Non-Euro II	Euro Area III
$gbdl_{-1}$	-0.014	-0.010	0.004
$Net_{-1} \cdot gbdl_{-1}$	1.274***	1.169***	-0.030
$lvol\_USD_{-1}$	-0.168**	-0.373**	0.014
$Net_{-1} \cdot lvol\_USD_{-1}$	2.190	4.833	0.197
d_USD_{-1}	-0.007	-0.010	0.003
$Net_{-1} \cdot d\_USD_{-1}$	1.308**	1.072**	2.182
$Net^2_{-1} \cdot d\_USD_{-1}$	-11.97*	-8.943	-45.12
Net_{-1}	-1.356	-2.196	3.642***
Net^2_{-1}	2.688	40.500	-39.73***
$C^{\bar{F}X}{}_{-1}$	0.166**	0.127*	-0.005
$D^{\bar{F}X}{}_{-1}$	-0.007	0.009	0.002
d_UIP_{-1}			
BG	-0.476	-0.449	
HU	-0.111	-0.170	
LV	0.314**	0.300**	
RO	0.050	0.067	
RS	0.026	0.026	
HR	-0.121	-0.118	
CZ	0.452	0.461	
DK	-0.366	-0.352	
GB	-0.438	-0.342	
GR	0.035		-0.199
IT	0.474		0.462
SI	0.009		-0.206*
SK	-0.098		0.071
AT	-0.057		-0.034
DE	0.173		-0.027
EE	2.657*		
d_CIP_{-1}			
BG	0.426	0.528	
HU	-0.405	-0.353	
LV	-0.732***	-0.724***	
RO	0.277	0.260	
RS	0.116	0.120	
HR	0.002	-0.034	
CZ	-1.086	-0.964	
DK	-0.020	-0.046	
GB	1.140	1.107	
GR	0.375*		0.135
IT	-0.179		-0.010
SI	0.199		-0.018
SK	-0.498**		-0.455***
AT	-1.608***		-1.218**
DE	0.176		0.149
EE	-1.410		
R^2	0.26	0.3	0.20
R^2 adjusted	0.15	0.18	0.06
Nobs	459	257	183
No. cross sections	16	9	6
Sample period	Full	Full	Full
Fixed effects	Yes	Yes	Yes

Table 6: **Robustness to allowing parameter estimates for *cip* and *uip* to vary across countries**

The Table shows results from regressions of valuation adjusted bank net wholesale funding flows in percent of total assets, for the full sample of countries, the subsample of non-euro countries and the subsample of euro area countries. Specification III excludes Estonia. The sample period runs from Q1 2007 to Q1 2016. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels, respectively, using white cross section standard errors and covariances.

	All I	Non-Euro II	Euro Area III
$gbdl_{-1}$	-0.011	-0.027	0.012**
$Net_{-1} \cdot gbdl_{-1}$	1.356***	1.435***	-0.280
$lvol\_USD_{-1}$	-0.200**	-0.290	-0.048
$Net_{-1} \cdot lvol\_USD_{-1}$	1.133	2.224	0.428
d_USD_{-1}	-0.005	-0.017	0.011
$Net_{-1} \cdot d\_USD_{-1}$	1.410**	1.272**	0.862
$Net^2_{-1} \cdot d\_USD_{-1}$	-12.11*	-9.377	1.817
Net_{-1}	-3.948	-6.931*	6.192
Net^2_{-1}	0.909	28.901	-14.362
$C^{\bar{F}X}{}_{-1}$	0.138*	0.116	-0.065
$D^{\bar{F}X}{}_{-1}$	-0.020	-0.028	-0.009
d_UIP_{-1}	0.021	-0.006	-0.161**
d_CIP_{-1}	-0.094	-0.079	0.046
$Growth_{-1}$	0.022	0.020	0.007
$Inflation_{-1}$	0.057	0.060	0.029
dUS_TS_{-1}	-0.135**	-0.350***	0.051
dUS_RR_{-1}	0.047	0.098	-0.031
d_USREER_{-1}	-0.010	-0.013	-0.005
DUS_M0_{-1}	0.003	0.017	-0.001
DUS_SFFR_{-1}	0.360**	0.516*	-0.001
R^2	0.25	0.32	0.22
R^2 adjusted	0.19	0.23	0.08
Nobs	421	238	166
No. cross sections	16	9	6
Sample period	Full	Full	Full
Fixed effects	Yes	Yes	Yes

Table 7: **Robustness to inclusion of additional controls**

The Table shows results from regressions of valuation adjusted bank net wholesale funding flows in percent of total assets, for the full sample of countries, the sub-sample of non-euro countries and the sub-sample of euro area countries. Specification III excludes Estonia. The sample period runs from Q1 2007 to Q1 2016. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels, respectively, using white cross section standard errors and covariances.

	All I	Non-Euro II	Euro Area III
$gbdl_{-1}$	-0.016	-0.016	-0.011
$Net_{-1} \cdot gbdl_{-1}$	0.375	0.410*	0.166
$lvol\_USD_{-1}$	-0.046	-0.005	-0.063
$Net_{-1} \cdot lvol\_USD_{-1}$	1.416	1.211	10.07*
d_USD_{-1}	-0.005	-0.008	0.020
$Net_{-1} \cdot d\_USD_{-1}$	-0.234	-0.424	0.240
$Net^2_{-1} \cdot d\_USD_{-1}$	1.294	4.155	-15.453
Net_{-1}	-2.293	-6.901**	29.55*
Net^2_{-1}	38.243	68.43***	61.748
$C^{\bar{F}X}{}_{-1}$	0.033	-0.007	-0.177
$D^{\bar{F}X}{}_{-1}$	-0.030	0.001	0.475
d_UIP_{-1}	-0.069**	-0.028	-0.629***
d_CIP_{-1}	0.103**	0.041	0.371
R^2	0.05	0.15	0.16
R^2 adjusted	0.00	0.08	0.07
Nobs	467	265	183
No. cross sections	16	9	6
Sample period	Full	Full	Full
Fixed effects	Yes	Yes	Yes

Table 8: **Regression for total cross border flows denominated in domestic currency** The Table shows the results for regression with the alternative dependent variable that includes domestic currency denominated cross border flows to foreign banks. Column III excludes Estonia from the euro area sample. The sample runs from Q1 2007 to Q1 2016 and all regressions include country fixed effects as well as the three explanatory variables. Asterisks *, ** and *** indicate significance at the 10, 5 percent and 1 percent levels, respectively, using white cross section standard errors and covariances.